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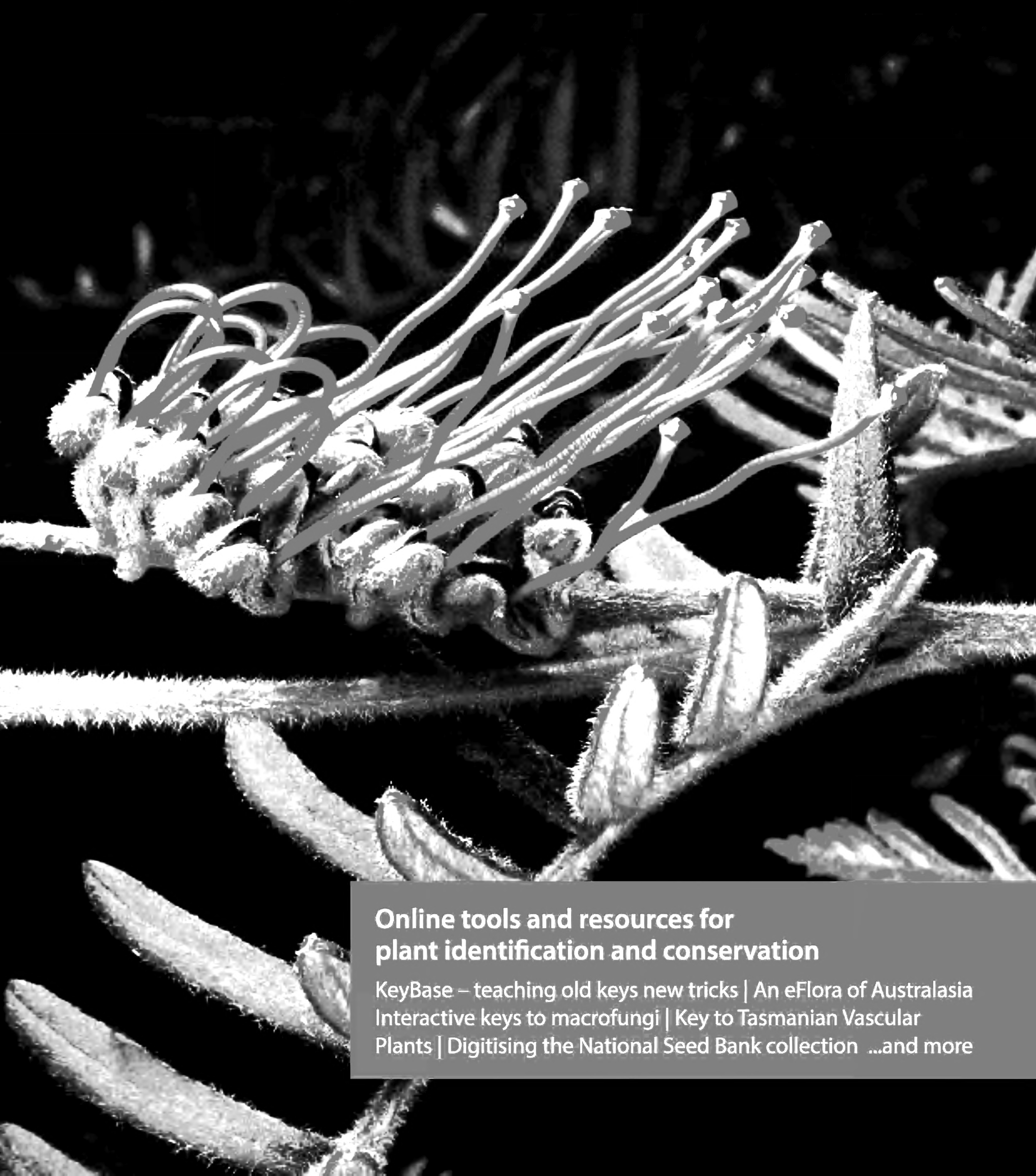

Online tools and resources for plant identification and conservation

KeyBase – teaching old keys new tricks | An eFlora of Australasia
Interactive keys to macrofungi | Key to Tasmanian Vascular Plants | Digitising the National Seed Bank collection ...and more

ANPC INC. MISSION STATEMENT: To promote and improve plant conservation

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Contributing to *Australasian Plant Conservation*

Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the September - November 2016 issue is 13 May 2016. The special theme for the issue is *the National Seed Science Forum 2016*. If you are intending to submit an article or wish to discuss possibilities, please email the editor, Paul Adam: editor@anpc.asn.au

Authors are encouraged to submit images with articles or information. Please submit images in electronic format, resolution needs to be at least 300 dpi, at least the size that they are to be published, in tif, jpg or gif format. Guidelines for authors and an article template are at: http://www.anpc.asn.au/apc.

Using the article template, please send articles, no more than 1200 words, as an MS Word file by email to: editor@anpc.asn.au.

This issue

Regular features

The production of this edition of *Australasian Plant Conservation* was supported by the **NSW Environmental Trust** through its Lead Environmental Community Groups program.

From the editors

PAUL ADAM AND ZOE KNAPP

The theme of this issue is online tools and resources for plant identification and conservation.

The ability to correctly identify plants is important for many reasons – having a name for a plant provides access to the accumulated information about that species, it enables communication and discussion, and for researchers it provides confidence that the plants they are working with are the same as those others have worked with. Correct identification may have considerable legal, planning and management consequences. For example, if the presence of listed threatened species is confirmed on a site, then it may determine the permissible uses of that land. Since the identification may be challenged in legal proceedings, botanists need to be very sure of their ground.

For several centuries botanists have relied upon printed works, known as floras, for plant identification. Floras can vary in their content and structure; some are merely annotated catalogues of the plants occurring in particular regions, and others include identification keys, which lead the user through sets of questions about the features of the specimen to be identified. Answering the questions sequentially will hopefully lead to the right answer. While some of us remain attached to hard-copy floras, they can be intimidating to some users, in part because they often employ complicated terminology. Identification keys can also be challenging to use. For example, traditional keys often focus on features of flowers and fruits, which are important for distinguishing many species, but this can make it difficult to identify plants from vegetative material, even though this material may have a range of characters which have potential for use in identification. Taxonomic concepts and nomenclature change, and species totally new to science are still being discovered. This means that many hard-copy floras are long out of date.

Today, advances in both computer hardware and software mean that we are no longer shackled to the couplets of classical keys. The theme of this issue of APC was inspired by the “Integrated Floras, eFloras, and online keys” session of the 2015 Australian Systematic Botany Society conference - for an overview of this session, see the article by Schmidt-Lebuhn in the previous issue 24(4) of *Australasian Plant Conservation*. Several of the articles herein are based on presentations at the conference, and others are new contributions based on the theme.

Kevin Thiele and Niels Klazenga, and Zoe Knapp *et al.* provide introductions to the rapidly emerging field of dynamic online approaches to identification. Tom May discusses the development of FunKey for higher fungi – given the great growth of interest in mushrooms and their allies in Australia there will be many fungi foragers for whom FunKey is likely to be a great boon. Tom also points out that modern methods for producing identification tools could change the historical progression of taxonomy followed by key production. For example, databases of species attributes can be used to generate keys, but also allow for the ready production of standardised descriptions of taxa.

Frank Zich and RaeLee Kerrigan discuss the history and development of The Rainforest Key. For those trying to identify rainforest trees and shrubs, flowers are often absent, or inaccessible, high in the canopy. Leaf and bark characters, and the presence of features such as buttresses are often all we have to work with. The rainforest key was constructed using many attributes, including vegetative character, so identification to species level is frequently possible in the absence of flowers.

Louisa Murray *et al*. and Greg Jordan discuss new resources for plant identification in New South Wales and Tasmania respectively. One New South Wales initiative is the development of a Facebook group whose members can post images and ask questions to tap into the accumulated wisdom of other group members. There is clearly great potential for specialist groups to develop similar collaborative assistance with identification. Greg Jordan has built upon the existing floras of Tasmania to develop a user-friendly online identification key, tested during its development by being exposed to the critical views of undergraduates. Greg shows that with limited funding and other resources it is possible for a dedicated few to produce effective and adaptable identification aids.

In addition to articles on the theme, this issue also includes the last article in the series about restoration projects by Dan Cole and Greg Siepen. This covers the important topic of monitoring, which is an essential, but often under-resourced, part of any restoration project, particularly in helping us learn from experience. Dan and Greg highlight the importance of documenting social responses to projects, and not just the ecological outcomes. Brook Clinton and Lydia Guja discuss the development of a new resource of digitised seed images, which will be important for ecologists and palaeoecologists, and potentially a source of new characters in taxonomy.

In our regular columns, the contribution from The Australian Seedbank Partnership, by Shane Turner and his colleagues, discusses resources for restoration of mine sites – certainly one of, if not the, largest challenges facing us in coming decades across Australia. The Member Profile introduces a prominent active member to the wider membership – Zoe Znapp, the guest editor of this issue. There are reviews of a number of new publications from CSIRO Publishing, and Workshop Reports from successful events in which ANPC, through its dynamic Project Manager, Martin Driver, has been involved. John Turnbull outlines a new initiative, funded by the NSW Environmental Trust, in which the Tweed and Byron Councils will develop a native species planting guide and related resources for residents. Lastly, but certainly not least, Kirsten Cowley's Research Roundup documents highlights from the recent scientific literature.

KeyBase – teaching old keys new tricks

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Plant identification keys are important for a wide range of people with an interest in, or need for, identifying plants, from environmental consultants, ecologists, conservation practitioners and researchers to field naturalists and members of the public. While some casual users may be able to adequately identify many plants of interest using pictorial field guides, anyone who really needs to know the name of a plant will generally need to use a key.

Most identification keys are printed and take the form of so-called dichotomous keys (better called pathway keys) comprising a branching tree structure with pairs of "leads" each of which directs to another pair of leads. A user chooses at each step which of the pair of leads best describes the specimen being identified, then follows the lead to another choice and so on, ultimately arriving at the name of a species or other taxonomic group. Such keys will be familiar to anyone who has used a Flora, or is familiar with taxonomic literature, and are very effective, well-understood and efficient means to an accurate identification.

Keys like this are usually printed in books, scientific papers or monographs; indeed, the most common forms of pathway keys we use today were invented specifically for efficient printing and page layout. This immediately creates a number of disadvantages for users. Keys are widely dispersed in the literature, often in works that are inaccessible to most users. Being found in printed works, they are also often out-of-date shortly after they are printed. These disadvantages limit the utility of pathway keys in the age of the internet.

KeyBase (http://keybase.rbg.vic.gov.au/) solves both these problems. KeyBase is a freely accessible, online keys repository and management system, created by active taxonomists and systematists to allow easy, single-portal access to a large number and wide variety of keys. Once keys are uploaded to KeyBase, they can be displayed in a variety of ways, both traditional (as coupleted or bracketed keys similar to those seen in books) and new (using an interactive key player). Being online means KeyBase keys are readily accessible without needing to be hunted down in books or journals. Online management of these keys also means they can be more readily kept up-to-date in the face of changing taxonomy, such as changes of names and discovery of new species.

Managing keys in KeyBase also allows us to do things with keys that are impossible with paper-based formats. Species and other taxa in KeyBase keys can be readily linked to other online resources such as species profile pages. Keys can be readily linked together to create nested sets of keys (for example, a key to families linked to keys to genera for each family, linked to keys to species for each genus, and so on as necessary). Keys can be mixed and matched in this hierarchy – if a new and better key becomes available, it can be readily "swapped in" for an older key without breaking the hierarchy.

Keys in KeyBase can also be filtered, one of the most powerful opportunities of a digital, online environment. Imagine that you have collected a set of specimens from a given locality. It is likely that any given key will have more taxa in it than occur at or near that locality. For example, if you collect a specimen of, say, an *Eremophila* from near Alice Springs, there is likely to be only a limited number of *Eremophila* species that are in contention for an identification (all species known or likely to occur around Alice Springs; the many species that do not occur

anywhere near Alice Springs are unlikely for the collected specimen). If you can obtain a listing[1] of all species of *Eremophila* from the Alice Springs area, KeyBase can accept the list (pasted into a list box) and will filter the *Eremophila* key, removing all taxa not in the list to present a key to *Eremophila* species of the Alice Springs area. A filtered key is likely to be much shorter and simpler to use than the original key, and is more likely to provide a correct identification (as long as the original list of species is correct).

Future developments in KeyBase will provide even more opportunities for teaching old keys new tricks, including support for illustrated keys and for automatic, in-line glossaries, both designed to overcome the sometimes daunting terminology used in conventional botanical keys. While access to KeyBase currently requires a web connection, it is likely that future developments both within KeyBase and as part of the eFlora of Australasia project will see "detachable" versions of keys and eFlora treatments that can be downloaded to a device and used in the field in places where web access is unavailable. For more information about the eFlora of Australasia project, see article by Knapp *et al.* in this issue.

KeyBase currently includes over 5000 keys to over 45,000 taxa.

KeyBase projects

Keys in KeyBase are arranged into projects, each of which usually comprises a linked set of keys to a particular taxonomic group (e.g. flowering plants, ferns, mosses) in a particular geographic region (e.g. Australia, Victoria, California). The largest current project is the *Flowering Plants of Australia* project, which includes nearly 1500 keys to more than 15,000 taxa. The aim of this project is to build a comprehensive set of linked keys that will allow the identification of any species of flowering plant, whether native or naturalised, from anywhere within Australia or its island territories. Keys in the *Flowering Plants of Australia* project include all Australian species, and hence can be used anywhere in the country. Other significant projects in KeyBase include the *Flora of New South Wales*, *Flora of Victoria*, and *Vascular Plants of California*; each of these is essentially complete for their respective regions. Projects under active development but still incomplete deal with the flowering plants of Queensland, Tasmania and Western Australia.

The *Flowering Plants of Australia* project represents the most comprehensive resource built to date for identifying Australian native and naturalised plants. Many keys are sourced from published *Flora of Australia* treatments; others come from recent taxonomic publications that have superseded *Flora* treatments, and from unpublished keys provided by a wide range of botanists. It includes all available pathway keys for Australian plants that are national in scope, and currently includes over 60% of APC[2]-accepted species, over 80% of APC-accepted genera, and over 90% of APC-accepted families.

A current project funded by the Australian Biological Resources Study (ABRS) is working towards completing the *Flowering Plants of Australia* keys. Two main steps in this are (1) updating the taxonomy in the existing (sometimes out-of-date) keys to harmonise with the APC and (2) creating new keys to fill gaps in the existing key set. Most genera for which there is currently no key in the *Flowering Plants of Australia* project have five or fewer species; writing a new key for such genera is often relatively straightforward.

Importantly, KeyBase provides an important and convenient platform for updating keys as necessary. Once the *Flowering Plants of Australia* project is complete, it will be possible to establish world's-best taxonomic practice in Australia by encouraging or requiring taxonomists who describe new species to update any relevant KeyBase keys. Such a system would be ideal for users and taxonomists alike, and will ensure that accurate identifications can be made by all, at any time, whenever necessary.

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1 A listing of taxa for a given region can be obtained from the *Australian Virtual Herbarium* (http://avh.chah.org.au)

2 Australian Plant Census. The APC is an agreed checklist of all recognised Australian vascular plant species. See https://biodiversity.org.au/nsl/services/apc

An eFlora of Australasia: a collaborative and dynamic online platform for managing Floras

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Introduction

The Australian Biological Resources Study (ABRS) and the Council of Heads of Australasian Herbaria (CHAH) have partnered with the Atlas of Living Australia (ALA) to develop an Australasian eFlora platform (herein referred to as the eFlora platform). The eFlora platform project responds to an identified need among the botanical community for an effective and efficient platform for collaborative creation, editing, sharing, management and deployment of flora content.

The eFlora platform is an important initiative in Australia and New Zealand. It provides opportunities for each country, individual states within Australia, and local regions, to flexibly develop online Floras including the ability to share information and content between species profiles. Importantly, the platform connects and integrates information from other sources, including nomenclatural information from the National Species List (NSL) (https://biodiversity.org.au/nsl/services), dynamic distribution maps from Australia's Virtual Herbarium (http://avh.chah.org.au) which is currently hosted by the ALA, interactive identification keys from Keybase (http://keybase.rbg.vic.gov.au), and images from the Australian Plant Image Index (APPI) (https://www.anbg.gov.au/photo/image-collection), as well as other biodiversity data from the ALA. In this regard, the eFlora platform represents the world's first fully integrated, collaborative and dynamic platform for building and managing Floras, and provides an important model for other international Floras. The platform also provides the basis for any profile based knowledge system outside the botanical community.

Progress on platform development

Following an initial scoping workshop in early 2014, the project was advanced with the formation of an eFlora Steering Committee involving representatives from the partnering organisations (ABRS, CHAH and the ALA). Continuous communication was maintained throughout platform development, including an online stakeholder group forum. Software development used an agile programming approach, with regular prototype releases followed by feedback from the user community. Ad hoc expertise groups were formed as needed to solve specific issues. A final prototype was released in mid-September 2015 for an initial round of user testing. The prototype enabled review of functionality for creating, editing, attributing and delivering content through the eFlora platform.

A coordinated testing program was run from September to December 2015, involving *c.* 30 representatives of state and national herbaria. The platform was tested using a selection of real data from various Floras including the Flora of Australia (FoA) and select state/regional Floras. Guidance was provided in a testing protocol developed by ABRS, and an eFlora platform training webinar conducted by the ALA and ABRS. Functionality and design aspects of the platform were tested separately. Functionality testing largely focused on workflow processes, including creating, editing and reviewing Flora treatments. Testers also reviewed more complex workflow processes, particularly regarding nomenclatural and taxonomic changes, e.g. through functionality for treatment versioning and archiving. In addition, a survey was conducted to seek feedback on designs of a number of existing Australasian eFloras (www.nzflora.info/index, http://eflora.nt.gov.au, www.flora.sa.gov.au/index, http://data.rbg.vic.gov.au/vicflora) in order to guide design of the final eFlora platform.

Feedback received through the testing program was sorted into nine key focus areas: platform architecture and navigation; name management; keys; mapping; images; Flora building and management; PDF outputs; page design; and miscellaneous issues.

Next steps and expected outcomes

The eFlora platform is close to providing functionality for building Floras. The key remaining challenges include managing a continually changing taxonomic hierarchy in combination with dynamic editorial and taxonomic updates to Flora treatments. With parallel advancements in the NSL infrastructure, the eFlora platform is moving to incorporate closer linkages with the NSL to allow alternate taxonomic hierarchies to be used. Resolutions to remaining challenges will ensure the final product provides appropriate collaborative research infrastructure

for Australian and New Zealand botanists. It is expected a prototype of the platform will be released to the herbarium community in late 2016, with a production (public) release some time in 2017.

The eFlora platform will provide infrastructure that supports collaborative and flexible creation and delivery of online Floras. This will reduce duplication of effort in the creation and curation of Floras and enable more rapid publication of new treatments, leading to increased momentum with building current and comprehensive Floras. Additional benefits include improved access to data for using and creating flora treatments and associated data.

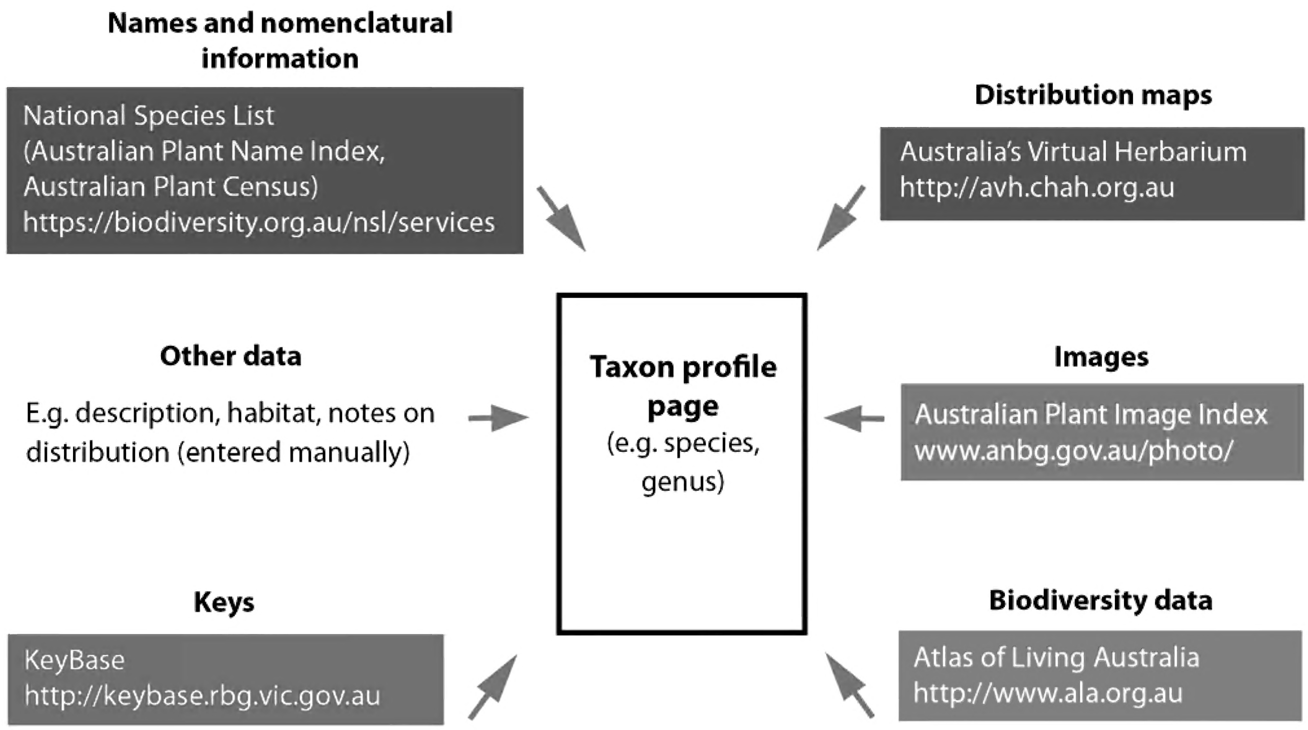
Governance and oversight

Moving to a dynamic eFlora platform inevitably changes the scope and management of traditional published Floras. For example, there are expected changes to the management of authorship, versioning and citations in a dynamic publication space. While some of these issues will be resolved through discussion relating to platform development, ongoing governance arrangements within the botanical community need to be established to provide clear oversight and decision making for managing Floras on the eFlora platform.

For the Flora of Australia, an advisory group has been established to oversee governance arrangements on the eFlora platform. This includes assisting ABRS with engagement of contributors and peer reviewers, and development of guiding principles for content management. The advisory group will also assist with reviewing new and revised taxonomic concepts to help harmonise FoA with the Australian Plant Census, developing guidelines for managing administrative, editorial and review processes, and informing decisions about the future management and operation of the eFlora platform. The advisory group will comprise the CHAH Executive, ABRS Director, nominated Administrator for the FoA on the eFlora platform, President or delegate from the Australasian Systematic Botany Society (ASBS), and representatives of key user groups.

Acknowledgements

We thank the Atlas of Living Australia, Council of Heads of Australasian Herbaria, Australian Biological Resources Study and the eFlora Steering Committee for their commitment and extensive work on the eFlora platform project. We also extend a special thank you to everyone who has been involved with testing the platform and providing essential feedback that has informed platform development.



Platform schematic showing the integrated data sources displayed in a taxon profile page. Each taxon (e.g. species, genus, family) will have a separate profile page that links together within a Flora. Information can be shared among Floras built on the eFlora platform.

FunKey or not so fun: creating interactive keys to macrofungi

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FunKey

FunKey - Agarics is an interactive key to the genera of Australian agarics (mushrooms) using Lucid software. *FunKey* is available on USB (May *et al*. 2014) or as an app for smart phones and tablets (Figures 1, 2). Compilation of *FunKey* took around a decade, during which time I had the pleasure of collaborating with Kevin Thiele (one of the developers of the Lucid software) and dedicated research officers Simon Lewis and Chris Dunk, as well as assistance from many people who provided photographs or tested earlier versions of the key.

Figure 1. ***FunKey – Agarics*** **runs from a USB or can be downloaded as an app**

Lucid interactive keys

FunKey, like all Lucid interactive keys, works off a data matrix consisting of features (characters) coded across all entities (taxa). Characters are either measurements (in which case the range is coded) or have two or more character states. For example, the character *pileus shape* has five states, including *rounded* and *plane*. Keying out is by a process of elimination – the user enters character states that are present, and any taxa not matching are eliminated (Figure 3).

FunKey has 159 taxa coded for 115 characters, of which seven are measurement characters, and 108 are multistate characters (with 376 character states). This means that there were more than 60,000 taxon/character state combinations, each of which had to be coded as present or absent (or unknown). This data matrix was constructed *de novo* for *FunKey*, which was a big task. During creation of FunKey, I learnt various lessons, some of which are shared here for the benefit of anyone thinking about constructing an interactive key: to fungi or any organisms.

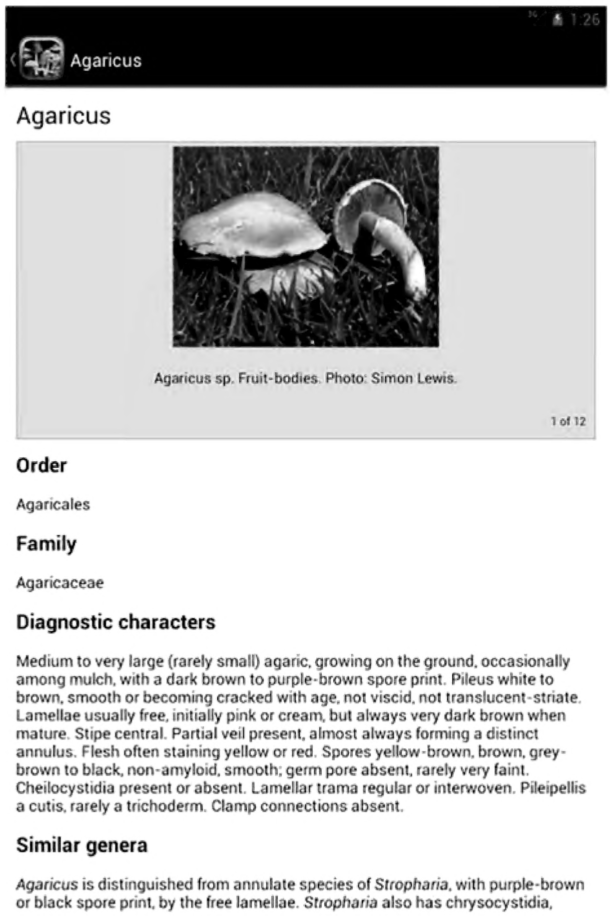

Figure 2. Taxon fact sheet from the app version of ***FunKey - Agarics***

The nightmare of generic splitting and lumping

The "genus" is a useful taxon for people getting to know fungi, and so building a key to genera seemed like a good idea at the start of the project. There were few keys to genera in the literature on Australian macrofungi, and most were out-of-date as far as generic concepts and were not comprehensive across all genera.

However, as soon the characters of the included genera were coded, new taxonomic arrangements appeared, in which genera were split or re-circumscribed. Sometimes a genus was split in two, but there were also more complex re-arrangements, where part of one genus was merged with another.

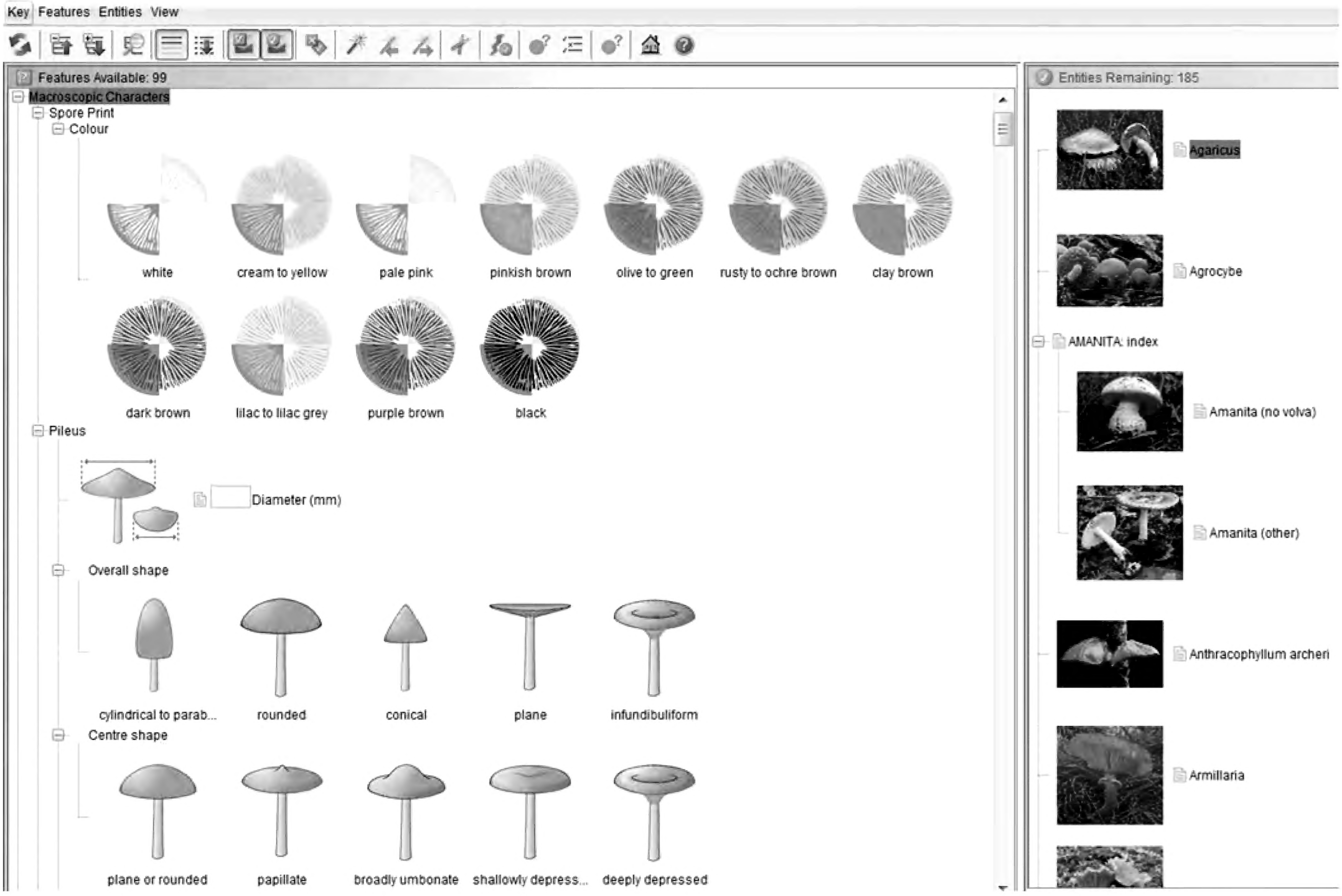

Figure 3. Lucid key window for *FunKey - Agarics*, showing character states on the left and taxa on the right.

The mutating genera were because agaric genera are now defined primarily on molecular characters, due to the amount of parallel evolution of morphology across different lineages. Consequently, there has been constant re-shuffling of generic boundaries to accommodate new insights from DNA sequence data.

It was a nightmare to re-code these newly defined genera, especially for genera with many species. All the characters had to be re-checked to make sure that a removed species did not exhibit unique character states for the genus as originally circumscribed; so that by removing the species, this character state no longer applied.

From experience in coding the morphing mushroom genera I strongly recommend coding individual species, even if you only want to make a key to genera. The species can be coded in a spreadsheet and then aggregated into genera, although for fungi, I would recommend always making the key to species, and letting the genera "self-aggregate" as the key is used (or not, depending on whether each genus actually has a unique set of morphological character states!).

Atomising of genera into species has the logical end point of atomising species into individual collections or descriptions; thus allowing for changes in circumscription of species. The choice to take this next step of atomisation depends on the stability of species delimitation in the particular group and the practicalities of maintaining multiple spreadsheets.

Getting the flow right: from funga to interactive key (or the reverse!)

Character coding was based on whatever information was available in individual published descriptions, taxonomic revisions, field guides, notes with fungarium collections and direct examination of fresh collections. The best source of data was the standardised description that is typical of funga treatments (a funga is a flora for fungi). However, for many groups of Australian fungi, there are no funga treatments. Indeed, there have been only three taxonomic volumes of *Fungi of Australia* published since commencement of the series in 1996; only one of which covers mushrooms. Perhaps it will make sense to create future fungas from keys?

Lucid facilitates creation of a natural language description of each genus, after characters are coded up. Once keys to species are created, this facility raises the possibility of coding up species from primary sources such as original descriptions and fungarium specimens, and then creating the standardised descriptions that characterise a funga (or flora). I think the concept of creating standardised

descriptions from interactive keys merits consideration by the publishers of *Fungi of Australia*, the Australian Biological Resources Study (ABRS).

Other lessons

Other lessons from compiling *FunKey* include:

1. When creating images, make sure you consider how they will look at thumbnail size when shown in the *Features available* key window (or on a phone or tablet). Lucid automatically creates thumbnails from larger images that are attached to each character state, but often fine details cannot be seen in these thumbnails, and we ended up creating some bespoke thumbnails (which were written over the auto-generated versions).
2. We spent a lot of time writing "help" and "how to" pages. However, when university students were observed using *FunKey*, they tended to rapidly click character states until their mushroom keyed out, and rarely looked at any of the help pages. The Lucid app version is set up differently to the USB version, and may cater better for this "click, click" approach, but it would be good to gather further data on the way that different kinds of users interact with the key.
3. We designed a "*FunKey* super session", with detailed instructions, using the *Sort best* and *Auto best* options, but these settings cannot be saved from one identification session to another, and I doubt many users are taking advantage of them. The option of saving these kind of settings would be good to include in future versions of Lucid.
4. Locking in your character/character state list as early as possible is ideal, because while it is easy to add taxa; when adding a character, you need to go back over all the data sources for all the taxa looking for this one character. Indeed, you might as well code up all available characters, and then non-discriminatory characters or characters that are too difficult to interpret can be dropped during the testing phase.

Overall, it has been a lot of fun developing *FunKey*. Kevin and I have been fortunate to receive additional support from ABRS towards constructing a key to waxcap mushrooms (Hygrophoraceae) – which of course, will be a key to species! We are also keen to make the framework of *FunKey*, especially the character images and fact sheets (Figure 4), available for anyone who wants to put together an interactive key to fungi.

Acknowledgements

Australian Biological Resources Study provided funding for the development of *FunKey – Agarics*.

Reference

May, T.W.**,** Thiele, K., Dunk, C.W. and Lewis, S.H. (2014). *FunKey: an Interactive Guide to the Macrofungi of Australia. Key to Agarics*. Version 1. [USB.] Identic, Brisbane and ABRS, Canberra.

[Also, app versions available from iTunes https://itunes.apple.com/WebObjects/MZStore.woa/wa/viewSoftware?id=958085767&mt=8 or Google Play https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.funkey&hl=en**].**

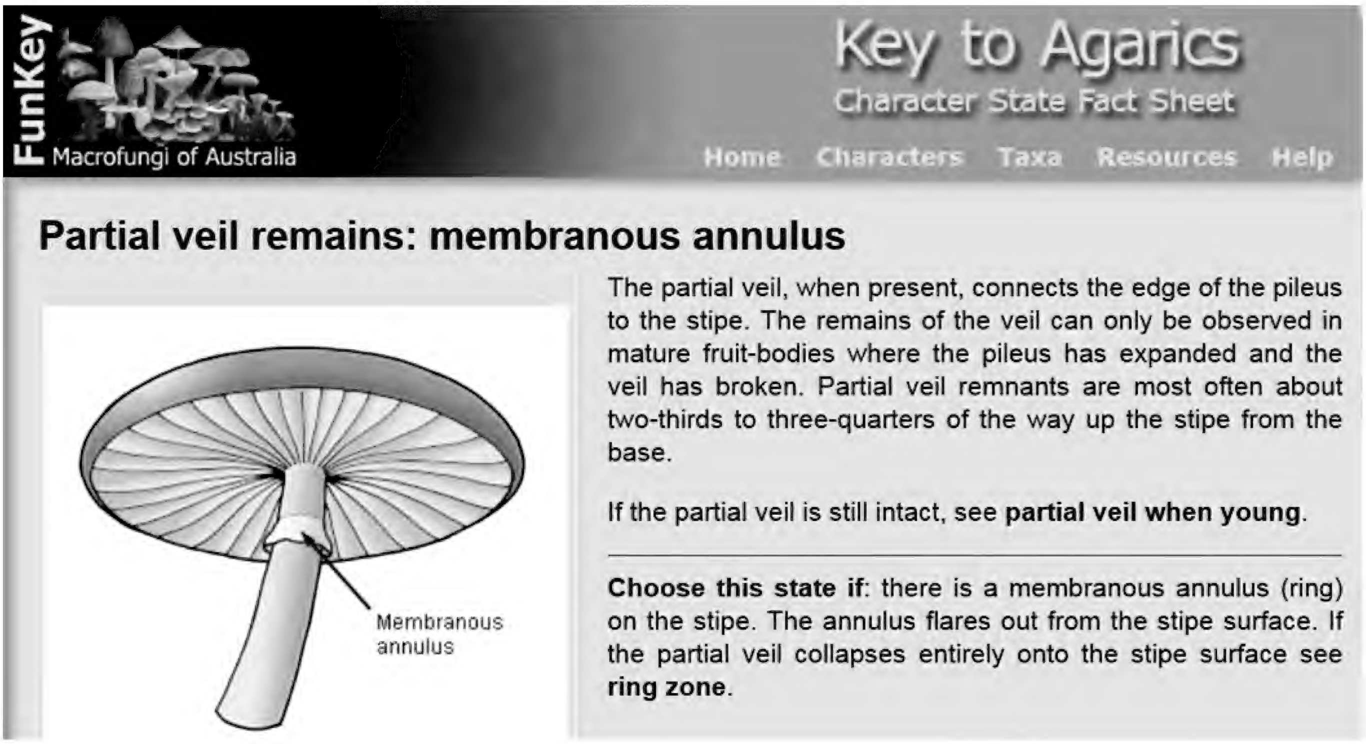

Figure 4. Fact sheet for a particular character state *membranous annulus*, as a state of the character *partial veil remains*.

Australian Tropical Rainforest Plants Identification System

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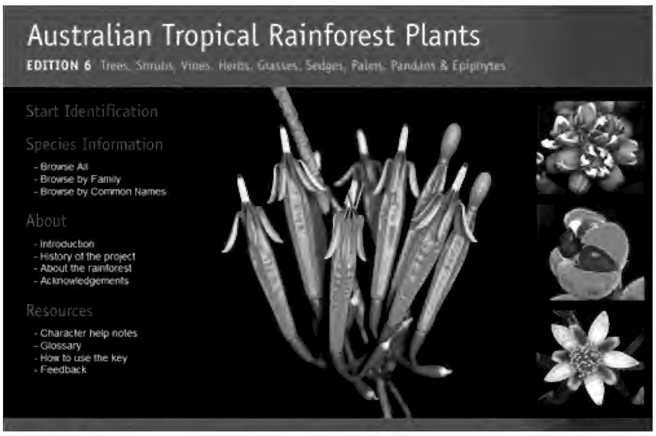
The *Australian Tropical Rainforest Plants Identification System* is a LUCID-based computer-aided identification tool for rainforest plants in northern Australia. It includes the vascular plants found in rainforest (including dry rainforest, or deciduous vine thicket) from Townsville to Cape York and west through the Northern Territory and Western Australia. The "RFK" as it is affectionately known by long-time users has been available online since late 2010. The RFK is a comprehensive, accessible and authoritative resource for identifying and learning about rainforest plants of northern Australia. For other Australian flora, including other biomes in northern Australia (e.g. savanna), resources for plant identification are dispersed in technical literature, inconsistent in format, taxonomy and geographic scope, and incomplete.

A fundamental aim of the tool is to be useful to anyone – from novices to knowledgeable amateurs and professionals - wanting to identify or learn about rainforest plants.

When first launched the online version consisted of 163 plant features coded for 2553 seed plant taxa. All major seed plant life forms were included - trees, shrubs, vines, herbs, palms, pandans and epiphytes. Subsequent development of the RFK has been modular, with new modules added for orchids (224 taxa and 51 characters) and ferns (334 taxa and 80 characters coded, and still in development). Maintenance and updating of the system continues with new, and newly recorded, taxa added and updating of plant names, geographical distributions, or coding.



The RFK is available online at:
http://www.anbg.gov.au/cpbr/cd-keys/rfk/

The RFK-Orchid module is online at:
https://www.anbg.gov.au/cpbr/cd-keys/orfk/

The RFK-Fern module will be available online for testing in 2016.

Development of the RFK

The RFK had its origin in the late 1960s with Dr Bernie Hyland at the Australian Tropical Herbarium – Atherton and has now been produced in six editions. The first two generations of the identification system were card keys, published in 1971 and 1982. In the late 1980s Bernie began collaborating with Dr Trevor Whiffin from La Trobe University to develop the RFK as a computer-aided identification system on disks, and each subsequent edition in 1993, 2000 and 2003 utilised current computer technology to deliver the best identification system possible with the most information available in the form of images and descriptions. At each step in this history, there has been an increase in the numbers of taxa, features coded and images to illustrate taxa, but the amount of information has partly been dictated by the available technology and taxonomic knowledge, and partly by the time and effort to collate information and images.

In 2010, the RFK and the RFK-Orchid module were launched as online identification tools in LUCID software. Since 2010 the RFK has been a very popular resource online with users able to launch the Lucid identification key or browse taxon profiles from the module, or even access taxon profiles directly by internet browser searches.

The online system is used by a broad range of people for a range of uses; from basic identification of plants and learning about the rainforest flora, to the identification of fossils of rainforest plants in New Zealand (e.g. Carpenter *et al*. 2012).

On average there are 1000 different visitors to the RFK homepage each month, and of these approximately half are returning visitors. Visitors to the website (over 28,000 since 2011) are coming from all over the world (Figure 1), unsurprisingly the majority (92%) are from within Australia (Figure 2).

Figure 1. Visitors to the RFK website are coming from all over the world.

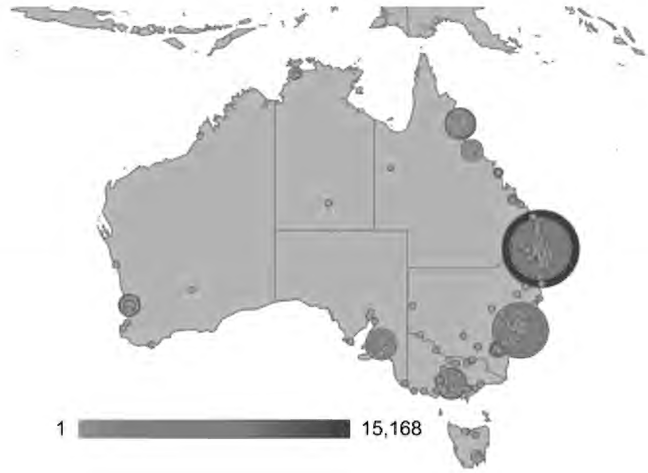


Figure 2. Approximately 92% of are from within Australia.

In 2015 a Bush Blitz Grant was awarded to the Australian Tropical Herbarium to extend the geographical coverage of the RFK. The Australian mainland rainforest flora is currently treated in two interactive keys (Harden *et al.* 2014; Hyland *et al.* 2010) together representing more than 3320 species. However, there is a c. 500 km gap between the geographical coverage of the two keys spanning Townsville to Rockhampton in central eastern Queensland. This project will complete the coverage of the Australian mainland rainforest flora by addressing this geographic gap which requires adding 200 species to the existing RFK coding and updating the coding and descriptions of species already within the northern area that extend to central Queensland. This project is funded for 18 months and will result in an updated online RFK that will provide a long awaited resource for the central Queensland region.

In March 2016 the project team visited Central Queensland to meet Irene Champion, Steve Pearson and other native plant enthusiasts in the area, including the Mackay Regional Botanic Garden and the Mackay Branch of the Society for Growing Australian Plants. The aim of the trip was to both introduce ourselves and the project, and to collect specimens and images of rare endemic species being grown at the Mackay Regional Botanic Garden and in the gardens of native plant enthusiasts. We are grateful for their generous hospitality and for the opportunity to be able to visit and use the herbarium and live plant collection at the botanic gardens. Special mention is also warranted of Steve Pearson who has been extremely generous in donating the use of his vast digital image collection to the project. His images will enormously enhance the taxon profiles to be developed for the Central Queensland species.

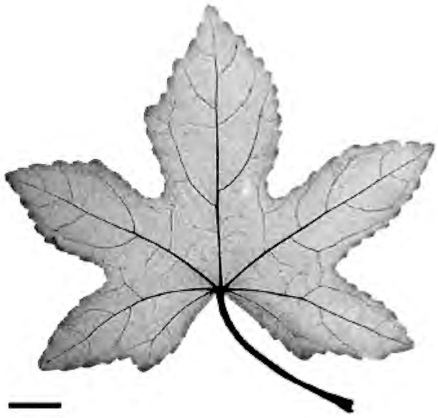
Next steps and how you can help

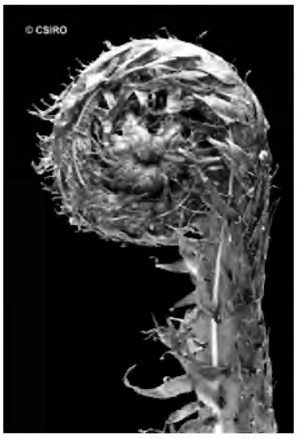
Initial plans are for the system to be available for use free online in 2017 but we plan in the coming years to produce a mobile app version and a USB version for portable use. This release will require a full update of the RFK for species names, distributions and other profile information.

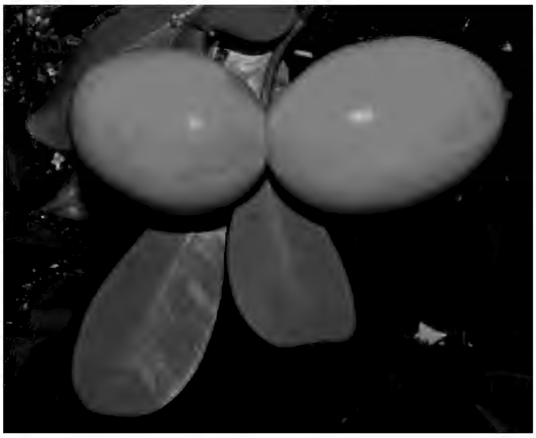
Once the revised RFK is ready to be released the project team will run workshops in the central Queensland region to train users in the use of the tool and in both basic and advanced aspects of plant identification. These workshops will be targeted towards a broad range of people including students, land managers, weed managers, council workers, and plant enthusiasts.

You can help contribute to the development of the central Queensland extension and updates to the entire RFK. In particular, we would appreciate images of plants including habit, flowers, fruit and bark. Ideally images would be vouchered by specimens accessioned into a herbarium but un-vouchered images would also be appreciated if the photographer can provide a confident identification and good background information on when and where the image was taken.

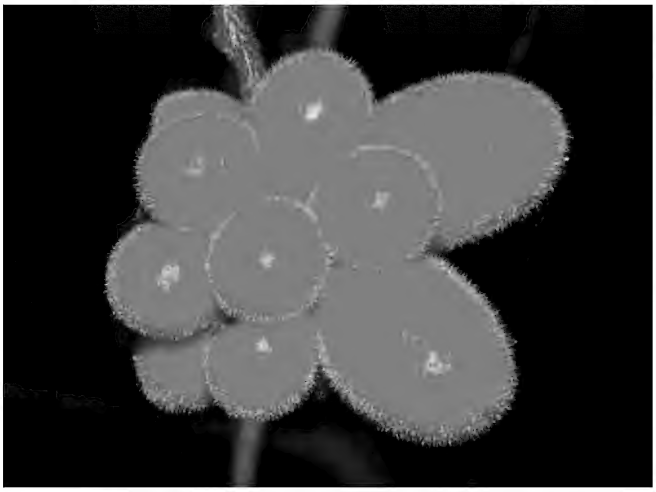
Raelee Kerrigan, Frank Zich and Irene Champion collecting samples at Mackay Regional Botanic Garden. Photo: Macleay Regional Council.







Left to right: Leaf xray of *Abelmoschus moschatus* subsp. *tuberosus*. Image: CSIRO. Crozier of fern *Diplazium queenslandicum*. Photo: Bruce Gray. *Neisosperma kilneri* fruit. Photo: Steve Pearson



Left to right: *Meiogyne heteropetala* fruit. Photo: Garry Sankowsky. *Omphalea celata* flowers. Photo: Steve Pearson.

References

Raymond, J., Carpenter, A.E., Jennifer, M., Bannister, B., Daphne, E., Lee, C. and Gregory, J. Jordan. (2012). Proteaceae leaf fossils from the Oligo–Miocene of New Zealand: new species and evidence of biome and trait conservatism. *Australian Systematic Botany* 25(6) 375-389. Doi: http://dx.doi.org/10.1071/SB12018.

Harden, G.J., Nicholson, H.R.W., McDonald, W.J.F., Nicholson, N.J., Tame, T. and Williams, J. (2014). *Rainforest Plants of Australia. Rockhampton to Victoria*. Gwen Harden Publishing.

Hyland, B.P.M., Whiffin, T., Zich, F. (2010). *Australian Tropical Rainforest Plants Edition 6* [online] <http://www.anbg.gov.au/cpbr/cd-keys/rfk/index.html>

***Elaeocarpus stellaris* flowers. Photo: Garry Sankowsky.**

How do you identify your plant?

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Identifying plants has often been a mystery to many and a dedication of a few. Historically, publications about the flora of a particular area or time period, also called "Flora" have been used to guide plant identification. Today, plant identification is supported by a combination of printed books, electronic resources, and social media. Here, we outline several useful tools for identifying plants in NSW and provide links to other Australian and international Floras and other tools for plant identification.

Doug Benson and Dr Peter Wilson with intern Nigel Holland deciding on the identification of a eucalypt. Photo: Louisa Murray.

Who needs to know the plant's name?

People and organisations who need (or are interested) to know the correct names of plants include local council officers such as environmental and weeds officers, agricultural officers, environmental consultants, bush regenerators, educators from schools, TAFEs and Universities, researchers, a tribe of fabulous botanical fanatics and the general public.

At the National Herbarium of New South Wales, Royal Botanic Garden Sydney we provide an identification service and we receive many interesting specimens from the specimens received. The submission of specimens by the public is extremely important for increasing our knowledge about the State's flora. For example, specimens can represent previously undescribed (new) taxa, and some represent new range records, or provide information about population level variation within species.

Rapid and accurate plant identification has become increasingly necessary, particularly given the rate of change in the landscape as a result of pressure from human activity and the need for conservation and land managers to assess proposals for future proposed activities.

PlantNET

At the National Herbarium of NSW, we have developed and maintain an on-line Flora called PlantNET. http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm

As an on-line Flora, PlantNET can be updated continuously and it is updated with new information overnight. This does not mean that it is completely up-to-date, in fact there are some major families (e.g. the orchids and the daisies) that need major revision. Taxonomic treatments of these taxa will be updated or incorporated into PlantNET as they become available. Useful functions of PlantNET include the ability to extract data for the list of species currently known to occur in a defined geographic area. Plant images, including both illustrations and photos, are provided to support plant identification. Maps provided in PlantNET distinguish between native and introduced taxa, which assists with weed management, and show the distributions of native plants, whether they be widespread or restricted to small areas. There is a function called "Weed Alert" that helps alert land managers to possible invasions of exotic species. There is also a particular search function for those rare taxa in NSW that need specialised management. New records of species come from additions to the Herbarium collection and many of these collections pass through our identification service: https://www.rbgsyd.nsw.gov.au/Science-Conservation/Plant-ID-Disease-Diagnostic-Services/Plant-Identification-Botanical-Information-Service

PlantNET helps us quickly identify specimens received at the Herbarium, so that we can provide information to our customers about the specimens, including whether they represent new taxa, (native or introduced), new variants or extensions to the species' known range. These records provide useful information about species distributions, including those that reflect possible impacts of climate change and other anthropogenic disturbances.

The data from these herbarium collections are fed into the Atlas of Living Australia (ALA, www.ala.org.au), to increase the accessibility and utility of the data.

This website is widely used to see where species occur. Note that occurrence data in the ALA maps includes observational records as well as vouchered herbarium specimen records. This is particularly important when taxonomic changes occur. While herbarium specimen data are gradually updated in line with taxonomic or nomenclatural changes (though this can take time), observation data are usually not updated and can eventually become obsolete. If a taxon is split, then in the absence of a specimen it is often not possible to decide to which of the segregates an old observational record should be referred. Some herbarium data are not up-to-date as some plant families have not been scientifically curated recently for a variety of reasons.

Plant Keys

The use of identification keys for identifying plant specimens has been part of the identification process for centuries. Identification keys can be dichotomous, or paired key systems, which use a process of elimination with usually one or two characters at a time being eliminated. While this can be extremely tedious and keys may contain errors, they are important tools for assisting with plant identification. Today there are electronic keys, for instance our key to the Acacias of NSW, where you can input characters from the specimen in front of you. This search usually results in a list of taxa and then it is a process of elimination. http://plantnet.rbgsyd.nsw.gov.au/PlantNet/WattleWeb/index.php

Names of plants

The most up-to-date websites to use for the names of Australian plants are the Australian Plant Census (APC) https://biodiversity.org.au/nsl/services/apc and the Australian Plant Names Index (APPI) https://www.anbg.gov.au/cpbr/databases/apni-search-full.html

The names in bold are the ones currently accepted. These websites are mostly up to date, and behind the scenes a committee of botanists from all States and Territories of Australia establishes the correct nomenclature.

Social Media

Social media groups are a great way for people from a broad demographic to meet online and discuss a common interest. NSW Native Plant Identification (NSWNPI) is a Facebook group where people can upload photos of plants that they wish to have identified as well as help others with their queries. It was created by Joel Cohen in late 2014 and now has over two thousand members.

The users of NSWNPI include botanists, taxonomists, botanical illustrators, ecologists, environmental scientists, bush regenerators, arborists, horticulturists, landscape designers, native bonsai enthusiasts, zookeepers, beekeepers, bushwalkers and even wildlife rehabilitators who need to identify food sources (foliage and nectar) for their animals.

The Facebook group works well because of the prevalence of mobile devices with the ability to take high quality images and ever increasing access to mobile reception. This means that members can take and upload images whilst in the field. The large number of contributors often means a quick and accurate identification is made whilst the person with the identification request is still on site. Some users are students who use the group to hone their identification skills as well as find mentors and receive recommendations for books and other resources. Other members have previous experience in the field but no longer work with plants and use the group as a way to keep in touch with other plant folk as well as ensure that their plant identification skills remain sharp.

The key benefit of NSWNPI is the presence of a large number of very knowledgeable users who are willing to share information. Plant minded people seem to be uniquely generous, with experts actively engaging in dialogue with members of various levels of expertise about technical, specific and difficult to obtain information.

We need your Feedback

Developing a Flora, whether a book or a website, is not an easy task. Certainly Google and social media have made knowledge about plants open to everyone. To those who use PlantNET and think it is great – thank you! If you find that some of the information is not quite right or are having trouble, please press the “contact us” button at the top right hand corner and tell us the problem.

If you have a plant that you would like to know the name of, we can help you through our Botanical Information Service.

https://www.rbgsyd.nsw.gov.au/Science-Conservation/Plant-ID-Disease-Diagnostic-Services/Plant-Identification-Botanical-Information-Service

Just send us your specimen. If it is a specimen of interest we often add them to the herbarium collection. Please press and dry your plant between sheets of newspaper and provide as much information as possible about the location and date of collection.

The future

An Australasian eFlora platform, through which the Flora of NSW (and other Floras) will be delivered, is being developed in partnership between the ALA, the Council Heads of Australasian Herbaria and the Australian Biological Resources Study. See the article by Zoe Knapp *et al*. in this issue.

For those working in remote areas, there needs to be downloadable versions of our floras with maps for use on the tablets and phones that we take with us to the areas where we collect. These tools need to be developed, which we hope to do as resources become available.

In order to maintain flora projects there needs to be adequate funding, at a national scale as well as within States and Territories, to keep taxonomy updated. These projects need to be on going, so the knowledge is up-to-date and available to all who manage biodiversity. Plants that are not fully included in our floras yet – the bryophytes, algae and fungi – require a lot more research before similar identification tools are developed (but see the article on fungi by Tom May in this issue).

Other useful websites

View full list: http://www.anpc.asn.au/apc-index

Grevillea caleyi. Photo: Jamie Plaza

The Key to Tasmanian Vascular Plants

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Introduction

The Key to Tasmanian Vascular Plants (http://www.utas.edu.au/dicotkey/) is an online tool for identifying native and naturalised Tasmanian plants. My central idea was to provide something useful for both professionals and amateur botanists. So, in building the key, I tried to make the steps in the key as simple as possible, to avoid technical language, to explain essential technical terms and, where possible, to use features that are present on the plant in any season and do not require a microscope. The key is backed up by many images of species and key characteristics. This simplicity comes at some cost of rigour, and involves subjective judgements – many features that are obvious to me are confusing for other people with different experience.

The key identifies all Tasmanian ferns, lycophytes, conifers and "dicots" (eudicots and basal angiosperms) to species level. It keys monocots to genera for most families but goes no further than family for grasses and sedges. It also provides short descriptive pages for each family genus and (except for monocots) each species. It includes good quality images of most species (approximately 4000 images of over 2000 species). It was most recently fully revised in 2013 and therefore misses recently recognised introductions and taxonomic changes (which are listed in the Census to Tasmanian Vascular Plants (http://www.tmag.tas.gov.au/collections_and_research/tasmanian_herbarium).

The design (Figure 1) is essentially that of a dichotomous key, with a page for each step – you click on an icon for the "correct" answer to proceed to the next page. There are also links to pages for individual families, genera and species as well as list of families, genera and species. It also has links for widely used common names and non-current taxonomic names. Each photo has an individual page. You can trace back your steps via a "back" key or a "bread crumb trail" – a list of previous steps.

How it was constructed

The key evolved rather than was planned. It started with a modest attempt to overcome a major problem in teaching undergraduate students to identify plants – how do they get past the first step of knowing what the family is? Family keys in formal floras are often difficult because of their need to satisfy taxonomic audiences. So in 2001, I built a simple paper-based key to native woody dicot families of Tasmania. In 2003, the University of Tasmania provided funds for developing electronic teaching resources, and my colleague, Robert Wiltshire, encouraged me to use some of this money to develop an illustrated electronic version of this key. Professional web designers created a highly flexible and remarkably simple design - a set of hyperlinked pages created from template pages for steps in the key, lists, families, information and photos (Figure 1). Anyone interested in the technical side can look at the structure by viewing pages in html.

A journey of a thousand miles starts with a single step. The flexibility of this framework means that over the next 10 years I used idle moments at work and my own time to expand this small key into a behemoth of over 10,000 individual pages, each created by editing existing pages. The editing was mostly done in Dreamweaver or Front Page. The former has better control of the overall structure and linking, the latter is simple for making small changes. Many people contributed photographs, and many others drew my attention to mistakes (and I am sure there are still many).

The good and the bad – is this a good way to solve the problem?

One benefit of this approach is that the job can be done bit by bit, with each stage being useful. It is also good at exploiting existing expert knowledge – much of the key was modified from the keys and descriptions in existing floras, especially Winifred Curtis and Dennis Morris' Students' Flora of Tasmania and Neville Walsh and Tim Entwisle's impressive Flora of Victoria. The computer part of expanding the key was easy enough; I am not an IT person and managed quite well. Transferring the technology to other keys is not difficult – see for example, in a Flora of Macquarie Island (http://www.parks.tas.gov.au/index.aspx?base=37552). Updating is also relatively simple for minor changes.

I am still happy with using this approach instead of a key developed using specialist packages such as Lucid. This feeling revolves around problems of apples and oranges. Many interactive keys (in which you simply select which characteristics you observe on the plant from a list) work well for groups of similar organisms (for instance, the Wattle key of Australian *Acacia*), but are problematic for more disparate groups. The problem is that different characters are important for different groups of plants, and different terminologies can be used for the same structures in different groups of plants. The key then needs to cover all bases and sometimes a ludicrous list of characters. In particular, automatically generated keys depend on a database of information on the species. Assembling this database for the Tasmanian vascular plants would be a terrifying prospect. For example, one would face the massive task of scoring each of 2500 species from 169 families for potentially hundreds of characters like "filiform hairs on the sepals". Even choosing the list of characters is a major

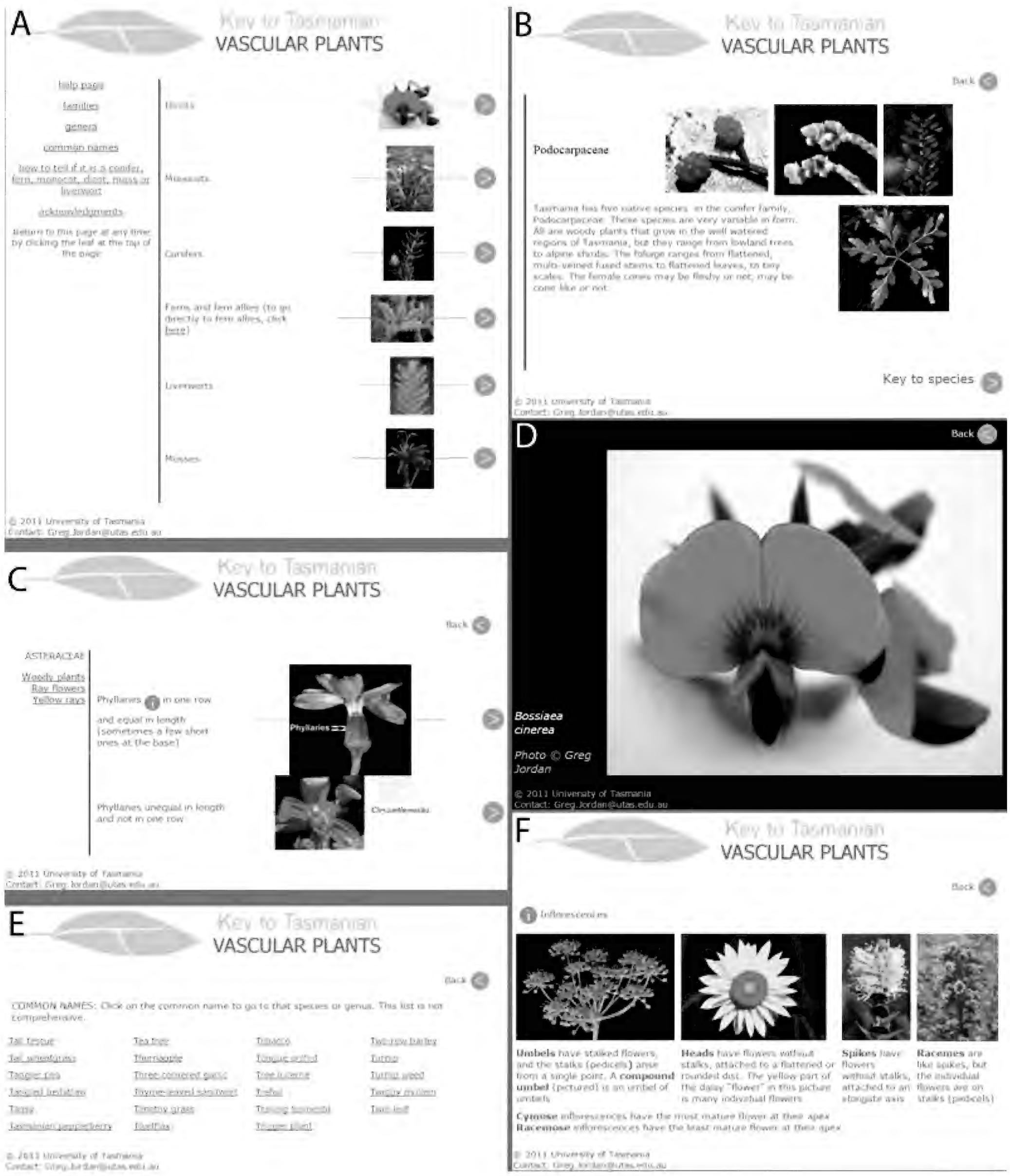

Figure 1. Some snapshots of pages from the Key to Tasmanian Vascular Plants. A. The main starting page, the left hand list takes you to some list pages and the right hand side is the first step in the key. B. A family page – there are also similar pages for each genus and (except for monocots) each species. C. A page for one step in the key – note the "i" icon that will take you to an information page. Note the bread-crumb trail on the left hand side showing the links to previous steps; and also the "back" button which will take you one step back. D. A photo page. E. A list page (in this case, common names beginning with "T", but there are lists for families, genera, species, etc). F. An information page explaining the differences in main inflorescence types.

job. Some packages can create dichotomous keys, but still have similar problems of character choice and scoring.

The main costs are that assembling and maintaining this key is a significant job and that major restructures are difficult. At present the amount of time that I can spend on maintaining and updating the key is limited (hence the lack of significant updates in the last three years, and also my failure to complete the monocots).

What about a mobile version?

The key is built as an online tool, but can be run directly from the original files. Phil Collier, from Threatened Plants Tasmania, tells me that he has successfully transferred the key to an Android mobile device, where it can be used with Firefox, and perhaps other browsers. I have the whole key on DropBox, and can provide access to this on request (just email me). It is possible that the key may be translated into an App at some stage in the dark future.

Considerations for large-scale biodiversity reforestation plantings. Part 8: project monitoring and evaluation

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Introduction

This article is the final in a series discussing considerations needed in large-scale tree planting for biodiversity outcomes. Monitoring and evaluation is key to understanding the successful aspects of the project and areas that need to be addressed to assist the required restoration outcomes. In this issue we discuss monitoring including the biophysical indicators of forest establishment through to the social indicators such as community attitudes towards such projects. The social context of reforestation at this scale is a future management consideration that requires improved planning so that these projects successfully integrate within cultural landscapes.

Project monitoring

Monitoring must include measureable indicators to determine if the project is reaching its objectives and within the required timeframe(s) that will typically be specified in the contract. Monitoring is important to restoration ecologists, project managers and other stakeholders as the process and data can provide a more comprehensive understanding of the restoration and also inform the design and delivery of future projects.

Considerable effort is applied in the planning phase to identify the following as a minimum:

- Historical disturbances, degrading pressures and associated risks
- Reference systems
- Mapping of management zones with corresponding species lists
- Planting methodology including restoration density

Monitoring some of these key aspects can provide invaluable information on whether the treatments have been successful or need to be adapted to assemble a forest community representative of the reference system(s).

For instance, there is limited understanding on restoration density for restoring some vegetation communities. The number of individuals planted and their spatial configuration affects the assembly of a forest and further monitoring and research will be required to optimize implementation of biodiverse forests particularly at the landscape scale.

Small planting sites which collectively add up to a large-scale planting should also be planted with species related to the local ecosystems that are being replaced, rather than what is currently available or “hardy”.

Project monitoring can be formal and informal, although due to the scale of such projects and generally limited funds available the latter is more common.

Informal monitoring

Informal monitoring can include visual assessment through reviewing satellite imagery and establishing photopoints. A series of photopoints at key locations with images taken prior to any works and then at regular

intervals (e.g. 6 months) can provide an exceptional visual summary of the project. Photopoints can easily capture the broad transitions from a degraded site to an established forest.

Site inspections and maintenance audits can identify works or issues that need to be resolved with the maintenance contractor(s) and typically provides a quality control path to satisfy technical specifications and beyond to achieve "off maintenance".

Routine inspections can identify problems such as herbivory or traits during establishment. For example, a rapid assessment can be undertaken to compare the "as implemented" species lists for the prescribed management zones at regular intervals to determine the trees that are prevailing or failing. This information can inform species selection for replants and future projects in similar landscapes.

Informal reporting even for internal records can track progress and ideally the transitions to success. This can include specific treatments, alternative interventions and maintenance activities such as any replanting. Tracking replants can reflect the "real" cost of restoration. Recording the tree stocking rates and associated costs throughout the project will capture the inputs required to achieve the target planting density.

Formal monitoring

Formal monitoring will include a monitoring plan with sampling methods underpinned by a condition assessment methodology which can vary between states. In Queensland there is the BioCondition manual produced by the Queensland Herbarium which provides a rapid assessment protocol for measuring the condition of an area of native vegetation.

It is important to have the baseline data prior to any restoration treatments. Control plots where no interventions have been applied are required to compare against the restoration plots. Sampling for biophysical systems in the restoration plots should be established randomly within certain areas such as riparian zones at the start of the project.

Formal monitoring is preferred. This can be undertaken by paid specialists within the contract budget or from community members who have time, skills and knowledge available to regularly collect data and analyse it to assist in adaptive management decisions.

Measureable indicators – biophysical and social

Biophysical indicators include the area of land restored, tree performance, biodiversity, soil productivity and hydrology amongst others. The social indicators can include community and landholder attitudes, the number of jobs created, training opportunities and the number of people participating in the project (e.g. volunteers).

Monitoring weed pressure and natural recruitment in a riparian zone. Photo: Dan Cole

Biophysical indicators

The following is a guide only and will depend on the contract's technical specifications, budget, length of maintenance period and monitoring plan that will detail the sampling frequency of:

- Tree performance through measuring survival, species, DBH and tree height
- Natural regeneration within the understorey
- Species richness and abundance
- Wildlife such as any indicator species (e.g. birds using framework tree species)
- Soil productivity such as water infiltration, organic matter, pH

If possible, differentiate between vegetative stems and those produced from seed as a measure of variability.

Social indicators

- Undertaking meetings with community members, farmers and other landholders to discuss the project
- Identifying any problems from the information gathered and monitor attitudes towards the project over time
- Reviewing existing information that is available such as local history and land use and gathering information on environmental, educational and recreational benefits to communities
- Documenting possible vandalism through monitoring visitors and plant damage.

It is important to understand the community attitudes and those of adjoining landholders so that large-scale reforestation projects are not only strategically located in the landscape as corridors to improve connectivity and other environmental values but that the location of these sites are sympathetic to the cultural landscape to be able

to successfully integrate with other land uses such as agriculture. Monitoring the social dynamics over time can inform where the greatest opportunities for reforestation will align in the landscape.

Monitoring partnerships and training

An option to assist a lack of funding and resources to be able to monitor large-scale reforestation projects can be to establish a monitoring group which could include multiple stakeholders such as landcare groups or education institutions. These groups could review the monitoring data and outcomes and recommend adjusting the monitoring plan if required. A multi-stakeholder monitoring group will not only allow each group to be represented it can also build trust and provide a foundation for mutual project ownership that may lead to future funding.

Training may be required in sampling methods and supervision essential so that the quality of the data is consistent. Technical professionals with monitoring expertise could train the group, if required. There is also potential for youth engagement programs which could introduce young people from schools and TAFE to ecological monitoring.

Monitoring should be undertaken for as long as possible within the budget or with community science volunteers (e.g. individual scientists, members of environmental and landcare groups) to collect data for future planning and management. This is often a neglected aspect of the whole planting process.

Assessing plant establishment in a riparian restoration project. Photo: Dan Cole

Monitoring site impacts and tree mortality after the 2011 flood event at the 2MT Wacol project. Photo: Dan Cole

Evaluation and Publications

Data analyses can be critical to understanding the successful areas of a project and likewise identifying areas for improvements so that adaptive management can be undertaken. It would be difficult to refine a monitoring plan without understanding what the data collection has indicated. However data analyses can be time consuming and expensive.

Linked to the monitoring and evaluation is reporting project outcomes to the client, community and other stakeholders. Publishing project outcomes, including discussion of problems which occurred, in relevant journals will assist industry development through more informed and refined methodologies, potentially minimising future problems and failures. Successful published outcomes can assist future funding for projects and enhance the reputation of ecological restoration.

Concluding summary

Monitoring is important so that indicators can be compared to the reference system(s) over time and therefore provide information on the trajectory of the restoration towards the destination of the target forest system. Monitoring can inform decision-making on restoration methodologies and adaptive management requirements that can lead to improved financial management and project outcomes. It is vital to engage with the community and landholders to communicate the intent of the project and to gain an understanding of stakeholder attitudes towards reforestation.

Images worth a thousand ideas: Digitising the National Seed Bank collection

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Why digitise a biological collection? Why are we preparing and sharing images of seeds?

The Centre for Australian National Biodiversity Research is creating a visual library of seeds. The image library will take the conservation collections of the National Seed Bank at the Australian National Botanic Gardens "out of the freezer" (where they are safely stored to extend their longevity) and make them available to the world. The seed collections are a valuable and carefully curated scientific resource, and therefore form the starting point for many avenues of further research. Creating a library of seed images serves to illustrate the considerable diversity of Australian native seeds. Such diversity is largely unexplored yet presents a multitude of opportunities for understanding the ecology of Australian plants, the careful use of seeds in landscape restoration, and even potential commercial exploitation of plant materials.

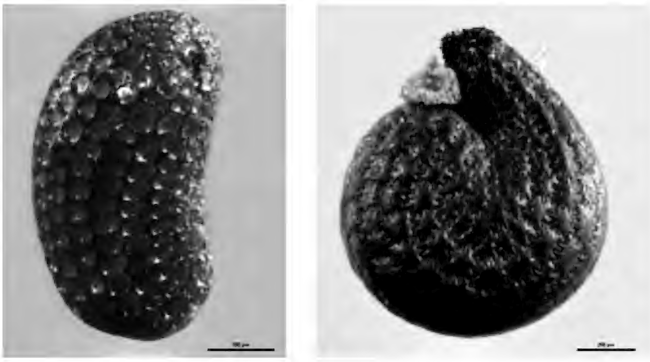
Seeds are fundamental to plant reproduction and dispersal. Despite these critical functions they are often overlooked. Larger organisms that exist on a human scale are more easily appreciated than seeds, which tend to be very small. However, with the assistance of microscopes even the tiniest details of the smallest seeds can be seen and marvelled at. In fact, this has occurred since at least 1665 when Robert Hooke published his beautifully illustrated *Micrographia*, including an investigation of the humble poppy seed. At first glance these small dark seeds appear to be round and smooth but closer examination reveals something entirely different. Hooke's drawings and subsequent photomicrography show the seeds to be kidney-shaped with a distinct raised honeycomb pattern. The beauty of this surface patterning can be surprising when first revealed to the viewer, but it is also very informative. The outer surface of these so-called "balloon seeds" (from poppies and other plants, particularly orchids) catch pockets of air for added buoyancy during dispersal (Kesseler and Stuppy 2006). In a similar way, digitising biological collections can inspire the general public (*Micrographia* was a hit back in its day), whilst simultaneously providing valuable insights into biological structure and function, leading to research and applications thereof that benefit us as we move within and responsibly exploit our natural world.

Seed morphology informs seed ecology

Morphological seed traits can provide clues as to the dispersal mechanism, ecological function, germination requirements, and identity of a species. Seeds and the fruiting structures that bear them can display a variety of structures and appendages that are integral to the dispersal of the seed to new growing sites. For example the particular geometry of a feathery pappus on a seed (reminiscent of a shuttlecock) can inform flight paths of seeds through the air (Fenner and Thompson 2005). A particularly common form of dispersal observed in Australian seeds is myrmecochory: dispersal by ants (Fenner and Thompson 2005). These seeds bear a specialised structure called an elaiosome; a type of aril containing a rich source of lipids and other nutrients that attract the ants to carry seeds back to their nests. Possible implications of myrmecochory include the prevention of seed predation or protection from fire (Fenner and Thompson 2005). Other seed structures such as awns on grass seeds often facilitate burial in the subsurface, thus affecting seed persistence and germination timing (Fenner and Thompson 2005). In many ways, seed morphology influences the complete lifecycle of the seed, but for many Australian plants we are only just beginning to uncover these finer details.

The unseen diversity of seed surfaces

One of the most intriguing aspects of viewing seeds under the microscope is the variation observable in surface patterning. Surface patterns are integral to species identification in some genera, e.g. *Spergularia* (Adams *et al*. 2008); however, only limited research into the function of surface patterns exists. Surface patterns may arise directly from the development of the seed but they may also be subject to selection due to certain evolutionary benefits (Kesseler and Stuppy 2006). Surface patterning of tiny seeds can reduce wettability aiding water dispersal (Kesseler and Stuppy 2006) and lowering colonisation by microorganisms, possibly even altering temperature variation in the immediate vicinity of the seed surface (Barthlott 1981). Smooth, round seeds may be adapted to withstand passage through bird/animal guts(Fenner and Thompson 2005). In these ways surface patterns play significant roles in plant life cycles, as well as being useful taxonomic features.



Left to right: *Bergia trimera* seed. *Dysphania kalpari* seed, showing surface patterning.

Digital image library

Although there is much to learn about our native plants, the good news is that we increasingly have better tools to investigate our beautiful yet rugged seeds (and the fruits that bear them). Two things that have changed since Hooke's time, in relation to biological imaging, are the advent of digital imaging technology and online biological databases. High-resolution images can now be efficiently generated using focal plane stacking and calibrated software to depict complex contours and intricate details, whilst enabling a suite of digital measurement options. Improved computing software, infrastructure and connectivity facilitate rapid generation of such images and their online accessibility.

The Australian National Botanic Gardens, Australian National Herbarium and National Seed Bank curate a scientific collection of plant material with concomitant tracking of all information relating to plant specimens and seed collections within the Integrated Biodiversity Information System (IBIS). IBIS provides an integrated framework of multiple interconnected databases, including the Australian Plant Image Index (APII, currently > 48 000 images). The newly created seed images will be hosted on the APII and eventually also available on the Atlas of Living Australia through an automatic data exchange.

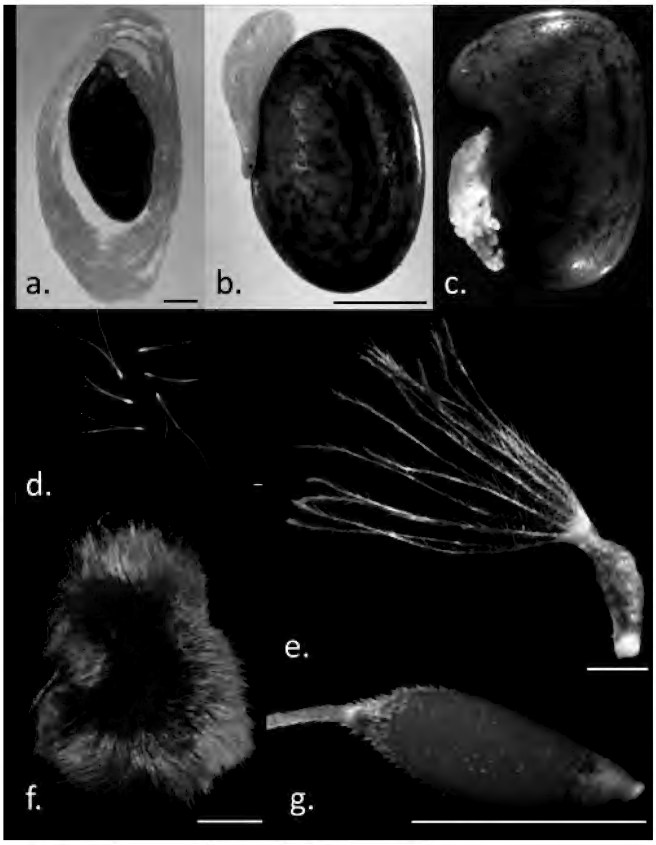
Consistent with a scientific collection, each seed image will represent a distinct plant species and a single collection event, associated with a specific accession of plant material. Plant material may consist of a seed collection stored in the National Seed Bank, a living plant growing in the Australian National Botanic Gardens, and/or a preserved specimen housed at the Australian National Herbarium. Therefore, all associated information managed by IBIS (e.g. locality of collection, subsequent germination trials) on the exact accession of seed that was imaged will be connected to the image via the unique accession number. The integration of seed images and their associated metadata into the botanical research collections will provide numerous opportunities for future research and utilisation of the collections.

Conclusion

Visual clues from our native seeds inform us about taxonomy, evolutionary history and many aspects of ecological function. Indeed, the collection or "library" of seed images is not a library in the usual sense, where knowledge gained through previous investigation is collated and stored. Rather, this library will be a collection of new biological knowledge and potential that we don't currently have access to. Australia's seeds are expected to yield many discoveries, for example, adaptations to arid and nutrient-deficient environments, and therefore resilience of plants in changing environments (Sweedman and Merritt 2006). While morphological traits are invaluable there is also growing demand for biophysical and germination traits to be made available for research (Jiménez-Alfaro *et al*. 2016) and digital tools will be critical for collating and making those data widely available.

Search for plant images on the Australian Plant Image Index: http://www.anbg.gov.au/photo/search-all-plant-short.html

Tip: to find images of seeds and fruit/dispersal structures, search "nsb" (National seed bank) in "class".



Seed structures and appendages; a. *Acacia tetragonophylla* b. *Daviesia latifolia* c. *Pultenaea baeuerlenii* (each of these showing arils attractive to dispersers), d. *Enteropogon ramosus* seeds with awns, e. *Leucochrysum albicans* seed with a feathery pappus, f. very hairy *Hibiscus brachysiphonius* seed, g. *Waitzia acuminata* showing tiny barbs that are not visible to the naked eye. Scale is 1mm.

Acknowledgements

The "Australian native seeds: a digital image library" project is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) Bush Blitz Program. Anna Monro from the Australian National Botanic Gardens kindly provided assistance in preparing this article.

References

Adams, L.G., West, J.G., and Cowley, K.J. (2008). Revision of *Spergularia* (Caryophyllaceae) in Australia. *Australian Systematic Botany*. 21: 251-270.

Barthlott, W. (1981). Epidermal and seed surface characters of plants: systematic applicability and some evolutionary aspects. *Nordic Journal of Biology*. 1: 345-355.

Fenner, M. and Thompson, K. (2005). *The ecology of seeds*. Cambridge University Press, Cambridge, UK.

Hooke, R. (1665). *Micrographia: or, Some physiological descriptions of minute bodies made by magnifying glasses*. J. Martyn and J. Allestry, London

Kesseler, R. and Stuppy, W. (2006). *Seeds: time capsules of life*. Firefly Books, Buffalo, NY, USA.

Jiménez-Alfaro, B., Silveira, A.O., Fidelis, A., Poschlod, P. and Commander, L.E. (2016). Seed germination traits can contribute better to plant community ecology. *Journal of Vegetation Science*. doi: 10.1111/jvs.12375

Sweedman, L. and Merritt, D. (2006). *Australian seeds: a guide to their collection, identification and biology*. CSIRO Publishing, Collingwood, Victoria Australia.

News from the Australian Seedbank Partnership

The Restoration Seed Bank Initiative – a focus on biodiverse restoration at the landscape scale

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Kings Park and Botanic Garden & The University of Western Australia, Perth, Western Australia
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The Australian Seed Bank Partnership (ASBP) is an alliance of 12 conservation-focused agencies across Australia (http://www.seedpartnership.org.au/. The Partnership undertakes nationally-collaborative seed banking initiatives as well as research to enhance the utility of native seeds in plant conservation and ecological restoration projects. Whilst seeds are at the heart of landscape-scale restoration, poor seed quality and low establishment can frustrate attempts to re-instate biodiverse plant communities (Merritt and Dixon 2011; James *et al.* 2013). With the growing recognition of the importance of landscape-scale ecological restoration in biodiversity protection comes an increasing demand for biological and technical knowledge of seeds. The Botanic Gardens and Parks Authority (BGPA), one of two ASBP Partners in Western Australia, leads a number of research projects aimed at improving restoration techniques and technologies using seeds which increasingly underpin major restoration efforts.

One of the largest of these projects, the Restoration Seed Bank Initiative (RSB) (http://www.plants.uwa.edu.au/research/restoration-seedbank-initiative), is a five year multidisciplinary research project that crystallizes an ambitious vision for the restoration of mine-impacted landscapes in the Pilbara region of Western Australia. The RSB unites the expertise and resources of BGPA, The University of Western Australia (UWA), and BHP Billiton Iron Ore (BHPBIO) to develop the science, knowledge, and technical skills required to achieve cost-effective and scalable environmental restoration. The RSB is not just about scientific endeavour, but also linking applied science with sustainable development, local communities, mining companies and government in a collegial partnership to provide tangible environmental, social and economic benefits.

The Pilbara biogeographical region of Western Australia is a major area of resource development (Ye 2008) – more than 90% of Australia's iron ore is extracted from the Pilbara. The disturbance footprint of established and emerging iron mine operations in the Pilbara is in the order of hundreds of thousands of hectares. Ecological restoration at this scale creates unique challenges, not the least of which is seed supply. Current seeding rates used for restoration average 5-7 kg per ha, meaning that at least 700 tonnes of wild-sourced native seed is needed to restore the 120,000 ha of disturbed land currently required to be rehabilitated (EPA 2014). Add to this the significant variation in the purity and viability of wild-collected seeds, as well as difficulties created by substandard seed storage conditions and lack of information regarding seed germination requirements, and seed science clearly becomes central to optimising restoration practices (James *et al.* 2013; Merritt *et al.* 2016).

Enter the RSB initiative; a project which commenced in 2013 that comprises four research nodes encompassing seedbank management and curation, seed storage, seed enhancement, and the use of alternative growth substrates or media. The focus of the project is to deliver the science needed for cost-effective restoration of biodiverse native plant communities, thus reducing the impacts of mining on the environment (Figure 1). The programs of the RSB are necessarily multi-disciplinary and involve plant scientists, soil scientists, and engineers; the complex biological problems associated with restoration cannot be solved by individual scientific disciplines or even individual institutions, but require collaboration and a long-term commitment and vision (Kildisheva *et al.* 2016). It is envisioned that the restoration template developed over the next few years from the RSB will be transferable to other regions of Australia, and beyond as the technology grows and matures.

Figure 1. A BHP Billiton Iron Ore restoration site on a waste rock dump several years after restoration work showing above average recovery and regeneration. This site was seeded using science-based seeding recommendations developed by the RSB research team. Photo: Brad Stokes.

Program 1 – Seed Bank Management and Curation

This program is focused on refining the seed handling and data management procedures to effectively curate seeds from all current and future BHPBIO seed holdings. Most of the seed used in restoration is collected from wild sources by the commercial sector, and then stored by the end user (i.e. the mining companies). Meticulous record keeping, along with sound seed handling practices are essential to ensuring high quality seeds are always available for ongoing restoration programs. An important aspect of this program is the training of environmental staff and seed users in seed curation and data base management.

Program 2 – Seed Storage

Storing a large amount of genetically representative germplasm for large-scale restoration requires knowledge of the seed storage behaviour of diverse species. Seeds are collected and banked over many seasons, providing stocks for future restoration programs and smoothing the supply during years when seeds are scarce in the environment – a particular risk in arid environments that experience irregular and patchy rainfall (Erickson and Merritt 2016). But to effectively manage the banked seeds requires data on their longevity under different storage conditions, and how these conditions might influence seed dormancy and germination behaviour. Optimising storage conditions ensures that seeds when eventually sown produce healthy, vigorous seedlings that have the best chance of *in situ* growth and development once utilised for restoration purposes.

Program 3 – Seed Enhancement

As one of the primary focal points of the RSB, this program aims to quantify and understand the environmental cues required to release seed dormancy and to define the conditions that promote germination and emergence under field conditions. Up to 70% of native species produce seeds with some form of dormancy and a key step in using seeds is to characterise dormancy types and understand how and when to apply germination stimulants such as smoke (Merritt *et al*. 2007). Nevertheless, once the problems relating to seed dormancy have been solved, it is still by no means assured that seeds will perform effectively in the field. Under current restoration approaches, seedling establishment is commonly less than 10% and new technologies are required to arrest the loss of seeds in the field. Through developing and adapting seed technologies such as priming, coating and pelleting (Figure 2), research is focused on enhancing germination and seedling stress tolerance, and aiding precision delivery of seeds through mechanised seeders (Guzzomi *et al.* 2016).

Program 4 – Growing Medium

Restoration following mining generally requires the re-introduction of plants into vastly altered soil substrates. As a consequence of current mining practices original topsoil is scarce, and mining waste material is abundant. Therefore, it makes good sense to examine the suitability of blends of these substrate types for plant establishment. Growth media must provide suitable conditions for seed germination, emergence, and subsequent growth; all of which are influenced by soil physical, chemical and biological properties. As moisture is the key limiting resource for germination in the Pilbara (annual rainfall is ~300 mm), the emergence of seedlings in various growth media under different temperature and rainfall conditions is a key focus of the research program. To explore the interplay between these critical environmental factors a 1,200m^2 purpose-built rain out shelter has been constructed at the BHPBIO Mount

Figure 2. Left: Recently sown seed pellets scattered across the soil surface. Right: recently germinated *Triodia* spp. seedling emerging from a pellet several weeks after surface sowing. Photo: Todd Erickson.

Whaleback mine in Newman which houses 64 irrigated research plots providing the ability to precisely field-test seed technologies under different soil and rainfall scenarios (Figure 3).

Conclusion

The research programs of the RSB reflect the challenges associated with landscape-scale restoration that cannot be solved by individual institutions alone, but rather require multi-disciplinary teams with a long-term commitment and vision, and a critical mass of staff and funding. There is a strong focus on collaboration and outreach to ensure the knowledge generated is accessible to the mining sector, landcare groups, and the restoration community in general. Whilst the focus is on the Pilbara region of Western Australia, the ultimate goal is to provide generic principles for enhancing seed-based restoration in other ecosystems.

Figure 3. Top: the recently completed RSB controlled environment facility (CEF) situated in proximity to active restoration sites. This shelter will test different restoration soil types (up to 64 at any one time) and watering regimes (up to 4) that will reflect current soils available for restoration purposes as well as likely rainfall patterns seeds and seedlings may naturally experience. Bottom: *in situ* emergence of Pilbara species after several weeks incubation in the CEF. Photos: Todd Erickson.

References

EPA (2014). *Environmental Protection Authority 2013-14 Annual Report*. Environmental Protection Authority, Perth, Western Australia - http://www.epa.wa.gov.au/AbouttheEPA/annualreports/Pages/default.aspx?cat=Annual%20 Reports&url=AbouttheEPA/annualreports.

Erickson, T.E. and Merritt, D.J. (2016). Seed collection, cleaning, and storage procedures. In T.E. Erickson, R.L. Barrett, D.J. Merritt and K.W. Dixon (eds) *Pilbara seed atlas and field guide: plant restoration in Australia's arid northwest.* CSIRO Publishing, Clayton. pp. 7-16.

Guzzomi. A.G., Erickson, T.E., Ling, K.Y., Dixon, K.W.and Merritt, D.J. (2016). Flash flaming effectively removes appendages and improves the seed coating potential of grass florets. *Restoration Ecology* doi: 10.1111/rec.12386.

James J.J., Sheley R.L., Erickson, T., Rollins, K.S., Taylor M.H. and Dixon, K.W. (2013). A systems approach to restoring degraded drylands. *Journal of Applied Ecology* 50, 730-739.

Kildisheva, O.A., Erickson, T.E., Merritt, D.J. and Dixon, K.W. (2016). Setting the scene for dryland restoration: an overview and key findings from a workshop targeting seed enablement technologies. *Restoration Ecology*, in press.

Merritt, D.J., Turner, S.R., Clarke, S. and Dixon, K.W. (2007). Seed dormancy and germination stimulation syndromes for Australian temperate species. *Australian Journal of Botany* 55, 336–344

Merritt, D.J.and Dixon, K.W. (2011). Restoration seed banks – a matter of scale. *Science* 332, 424-425.

Merritt, D.J., Golos, P.J. and Erickson, T.E. (2016). A systematic approach to seed management for restoration. In T.E., Erickson, R.L. Barrett, D.J. Merritt and K.W. Dixon (Eds). *Pilbara seed atlas and field guide: plant restoration in Australia's arid northwest.* CSIRO Publishing, Clayton. pp. 35-42

Ye, Q. (2008). Commodity booms and their impacts on the Western Australian economy: the iron ore case. *Resources Policy* 33, 83-101.

ANPC Member Profile

Zoe Knapp

What is your current position?

Scientific Project Officer (Flora), Australian Biological Resources Study (ABRS), Department of the Environment, Canberra

What are you working on at the moment?

I'm responsible for managing the production of the Flora of Australia, which was originally a planned series of ca. 60 printed volumes, describing the vascular plants, bryophytes and lichens of Australia to the species level.

More recently, I've been involved in an exciting project to develop an Australasian eFlora platform, in partnership between the ABRS, Atlas of Living Australia and the Council of Heads of Australasian Herbaria. The platform will provide an online tool for collaborative creation, editing, sharing, management and deployment of flora content, including the Flora of Australia. More information about the platform is available in our article in this issue.

Zoe Knapp at the 10th Australasian Plant Conservation Conference in Hobart 2014. Photo: Jo Lynch

How did you end up working in plant conservation?

I grew up in the goldfields region in central Victoria. At school, we were not only taught about "stranger danger" but also how to survive a snake encounter, survive in a bushfire, and how to avoid falling down mine shafts (my Dad found this out the hard way!). I spent a lot of time exploring the intricate details of nature and remember being completely in awe of it. My first pet was a beautifully coloured caterpillar and my siblings and I used to love chasing echidnas to watch them try to bury themselves in the dirt. Growing up surrounded by beautiful bushland gave me a wondrous sense of the beauty of nature, and I've been passionate about conservation and science ever since.

I studied a Bachelor of Science with Honours in Botany, and completed a PhD in 2006 at the University of Melbourne, which focused on the biology and reintroduction of threatened terrestrial orchids. I subsequently worked in environmental consulting, and undertook several international positions including as a visiting scholar at Sweet Briar College, Virginia, USA, postdoctoral fellow at the Smithsonian Institution, USA, and intern at the Royal Botanic Gardens Kew, UK. I joined the Department of the Environment's Graduate Program in 2012, and have been working at the ABRS since April 2015.

How long have you been involved with the ANPC?

I joined the ANPC Committee in about 2006, and was Secretary from 2009 to 2015. One of my fondest memories was helping to organise the 2009 ANPC Forum in Halls Gap. We had a wonderful group of presenters and attendees from various backgrounds, which resulted in some really interesting discussions about how to bring conservation science into management action. Being the ANPC Secretary was a great way to see the amazing range of work undertaken by a few passionate and dedicated volunteers, and contribute to plant conservation at the national level.

Book reviews

Plants of Central Queensland: Identification and Uses of Native and Introduced Species

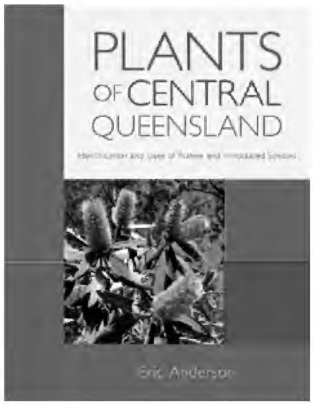
By Eric Anderson
CSIRO Publishing, Melbourne April 2016. 576 pp. ISBN 9781486302253 Hardback AU $160.
Available from www.publish.csiro.au

In the absence of a state-wide flora, regional accounts are often the only resource for helping people come to grips with local plants. Providing information on 525 species, *Plants of Central Queensland* covers an area extending roughly from Maryborough north to Townsville and inland to Longreach. Its purported aim (p. vii) is to help land managers "become better equipped to manage the vegetation resource on their land" through recognising and becoming more knowledgeable about the plants growing there. This is reflected in the criteria used to select species for the book, which are strongly associated with agricultural and pastoral land uses.

If the title sounds familiar, that's because an earlier version of the book was published in 1993 by the Queensland Department of Primary Industries. This second version (it's not called a second edition) has a slightly different title, covers 285 more species and includes many different photographs of, and often new information about, plants included in the earlier version.

The format is unchanged, with a page-long profile of each species. The common name (forming the title of each profile) is followed by the scientific and family name, with former names and alternative common names also included. The scientific and family names have mostly) (one exception noticed is *Sida subspicata* (p. 397), which has been called *S. hackettiana* since 2012) been updated, as needed, to those currently accepted in the *Australian Plant Census* (http://biodiversity.org.au/nsl/services/apc), with some family names reflecting usage adopted by the Queensland Herbarium (e.g. the use of Caesalpiniaceae, Fabaceae and Mimosaceae instead of just Fabaceae).

A short description of the plant follows in generally non-technical language, and covers habit, leaves, flowers (including flowering period) and fruit. The descriptions are adequate to distinguish between closely related species, and are supplemented by at least one photograph of the plant. The caption for each photo is informative, summarising the diagnostic features of the organ shown. Notes on the habitat follow the description, and generally cover vegetation type and landforms, with soil type provided for many of the herbaceous species. A map shows the species' general distribution in Queensland, and accompanying notes summarise its occurrence elsewhere.



Each profile concludes with general notes. Depending on the species, they include characteristics such as weediness (including the current declared pest plant class in Queensland, if relevant), palatability to stock and whether poisonous to them, timber value, usefulness as food for bees, butterflies and birds, reported medicinal value or use as bush tucker, and other interesting facts. Colour-coded symbols at the start of the notes allow immediate assessment of whether the species is a declared pest plant, has invasive potential, is poisonous, bush tucker, medicinal or bee food. The notes occasionally mention closely related species and how to differentiate them (e.g. swamp foxtail and fountain grass, p. 463), and sometimes include a photo of the second species.

The plants are grouped by type – ferns, palms and cycads, aerial plants, trees and shrubs, vines and creepers, cacti, herbaceous plants, water plants, sedges and matrush, and grasses. The pages for each group are colour-coded, with the colour bled to the edge making it easy to quickly select a desired group. The species included in each group are listed at the start of the section. Although listed (and presented) alphabetically by scientific name, the common name is shown first, making it cumbersome in the larger groups, if you only know a common name, to quickly skim through the list and find your target species.

Those unfamiliar with the region's flora or with little botanical knowledge will try to identify plants by skimming through the pages looking at photographs. For a 2016 publication (in the digital age), users will be disappointed at the standard of quite a few photos: they may be washed out, lack definition or colour balance, and compared with the 1993 version, may show less detail of things like the leaf and flower structure of a species. This appears to be the result of many illustrations being scans either of published photos or of slides taken by the author over many years, and reflecting the book's long gestation period. It's also disappointing that the on-line

resource *Australia's Virtual Herbarium* (AVH) does not appear to have been used either to update the general distribution maps of species included in the 1993 version, or to provide more accurate general maps for some species added into the current version. For some species where the whole of Queensland has been coloured (e.g. Murray lily, p. 343) the use of AVH would also have helped provide a more nuanced distribution map comparable to those for other widespread species.

Other niggling negatives are present. For example, there is no asterisk in front of the scientific name to indicate an exotic species. This makes it difficult to tell at a glance whether a plant is native or not (unlike whether it is a declared plant or poisonous), as the reader must scan down and read the distribution notes. While some information has been updated for the species in the 1993 version, other information has not. The former includes whether the species now has a different declared pest class status, or whether it provides food for the larvae of butterflies. An example of the latter is the grey mistletoe, said to be "Exclusively parasitic on species of *Acacia*" in both versions, but now known to be parasitic on other genera (see www.anbg.gov.au/mistletoe/mistletoe-checklist.html) with species present in the region.

Despite the niggles, *Plants of Central Queensland* provides an entry to identifying common species over a large area in Queensland. Overall, the book is easy to use, attractively presented, has a useful general reading list, separate indexes for scientific names and common names and contains very few typographic errors. While much of the information is aimed at local pastoralists, people with a general interest in plants and wanting to know more about them will also find it useful, whether residents or travelling through the region.

Rosemary Purdie, Honorary Associate
Australian National Herbarium

Vegetation of Australian Riverine Landscapes

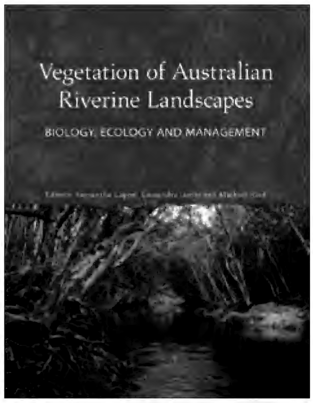
Edited by Samantha Capon, Cassandra James and Michael Reid
CSIRO Publishing, Melbourne. 2016. 440 pp. ISBN 9780643096318 paperback AU $140

Because of their historical utilisation and concentrated exploitation, riverine landscapes are among the most altered and in some cases most threatened landscapes on the Australian continent. They are still some of the most ecologically, economically and culturally significant landscapes for many of the same reasons. The publication of *Vegetation of Australian Riverine Landscapes* is significant in bringing together the results of substantial bodies of research from the last few decades to draw together a summary of these landscapes' distribution, description and management issues.

The book is divided into four sections: the spatial and temporal distribution; the key groups of riverine plants; habitats and the main vegetation communities in the five major regions of Australia; and the critical issues of management and restoration.

The collation of recent work is important in this publication and the references are extensive for recent work but not exhaustive for some of the earlier contributing work in some themes, i.e. earlier CSIRO geomorphology research leading to current understanding. This is not surprising in trying to further reduce the scale of what is an already comprehensive but expensive tome.

The coverage and content layout is extensive and gives a great overview of the main themes. Cost-cutting has obviously led to all plates being printed in black and white tonal. While this is a minor issue in not depicting the well selected photos to full expression, it has rendered several of the tonal maps and figures more difficult to decipher.



The coverage of topics and geographic coverage of the continent is excellent and the themes well laid out and outlined. The importance of riverine vegetation ecological services is mentioned in several places but may not give this topic the importance it deserves to argue the case for effective management and restoration of these resources. While the issues of vegetation management and restoration are outlined toward the end of the publication, full treatment is beyond the scope of this publication, and leaves an opening for a future detailed collated reference work of the opportunities, approaches, techniques and lessons from restoration and management efforts for each of the vegetation communities and regions.

In short, a great current reference for anyone working, interested in or wanting to know more about our iconic riparian landscapes in Australia.

Martin Driver, ANPC Project Manager

Workshop Reports

Sandhill Paddock Walk at Booroorban, south of Hay NSW – 1 June 2016

SALLY WARE[1]* AND MARTIN DRIVER[2]

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With the native vegetation bouncing back after a series of recent rain events following a long dry summer and autumn, a third successive Paddock Walk was organised in early June by staff from the Hay office of Riverina Local Land Services in conjunction with Landcare, Greening Australia and other agencies focusing on the Riverine White Cypress Pine Sandhills. This time the destination was the sandhill communities around Booroorban. Funding for the Walk was provided by the National Landcare program.

As with previous Paddock Walks, ANPC Project Manager and local Conargo property owner Martin Driver was the principal speaker. The day started with the twenty five participants meeting at the Royal Mail Hotel at Booroorban for refreshments and discussion of a native plant and resource display before the group moved to the local property "Zara". Situated near the Zara homestead is a fenced reserve that contains a long time preserved extensive sandhill vegetation community. The abundance of species in the reserve was breathtaking with many at the point of flowering and/or setting fruit following the rain. Some of the species observed included Shrubby Rice Flower (*Pimelea microcephala*), Native Jasmine (*Jasminum lineare*), Native Clematis (*Clematis microphylla*), Elegant Speargrass *(Austrostipa elegantissima*), a rarely observed seeding Rosewood (*Alectryon oleifolius*) as this plant usually reproduces by suckering, Narrow Leaf Hopbush (*Dodonaea viscosa* subsp. *angustissima*), Sandalwood (*Santalum lanceolatum*) and a seeding White Cyprus Pine (*Callitris glaucophylla*) with Martin explaining the difference between the fruits (cones) of a White Cyprus Pine and a Murray Pine (*Callistris gracilis subsp. murrayensis*). The differences between a fruiting Sweet Quondong (*Santalum acuminatum*) and a Bitter Quondong (*Santalum murrayanum*) were also discussed.

Following lunch kindly provided by the Royal Mail Hotel, the group drove to another local property "Elmsleigh" recently purchased by the Hooke family. The first site visit was to a proposed sandhill reclamation area followed by a stop at a neighboring State Forest reserve, which contained many local species including shrubs such as Senna (*Senna artemisiodes* subsp. *coriacea* and subsp. *filifolia*) and Yanga bush (*Maireana brevifolia*) and copperburrs (*Maireana* sp.) as well as young White Cyprus Pines and many Flax-Lilies (*Dianella* sp.) growing in the leaf litter. The final stop was to a fenced native Quondong plantation on the next door property "BurraBuroon" owned by the Butcher family where the prolific growth of Sweet Quondongs was observed and discussed. The next Paddock Walk will take place in early Spring with a return to "Zara" to observe fruiting and seeding sandhill species. Interested people can contact Sally Ware by email at sally.ware@lls.nsw.gov.au or by mobile 0429307627, Martin Driver by email at projects@anpc.asn.au or mobile 0400170957 or Michael Fayle at michael.fayle@lls.nsw.gov.au

ANPC Project Manager, Martin Driver (left), speaking at "Zara" on the Sandhill Paddock Walk at Booroorban on 1 June 2016. Photo: Annabel Lugsdin.

Barham Landcare Plant ID Workshop

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(this is an edited version of an article written by Christine Dartnell and printed in the Koondrook & Barham Bridge newspaper on Thursday 5 May 2016)

On Thursday 28 April a plant identification workshop was held at the Barham Federation Botanic Reserve near the Murray River in south west NSW. Alan Mathers, President of Barham Landcare, welcomed everyone to the first workshop at the Reserve, gave a brief introduction to the invited guests which included Keith McDougall from cluBarham, Esther Kirby, Aboriginal Elder and Martin Driver from the ANPC and the presenter of the workshop, and then thanked all the Landcare group's sponsors. Keith McDougall then officially re-launched the Reserve and told of how his family lived close to the Reserve and how it was once used to grow Lucerne. The Welcome to Country was then carried out by Esther Kirby, Aboriginal Elder for the Barapa Barapa and Wemba Wemba tribes.

Martin Driver was then introduced to take us into the plant world. Martin's background includes working with native vegetation for over 35 years with CSIRO, Greening Australia, Murray Indigenous Seedbank, Murray CMA seedbank, PlainSense Vegetation Management and the Australian Network for Plant Conservation. He has lived in the Riverina and operated his grazing property at Barrabool over that time and undertaken lots of restoration works and failed experiments.

Martin is also obsessed with management of native vegetation. He guided the group to reference material that is of benefit when identifying and recording native plants. Following a brief overview of native plants, the group then set off along one of the walking trails. Martin was able to identify and give a brief history of a lot of the plants along the way with an outstanding recollection. I am sure he must have dreams of native plants. His knowledge was immense and the group were well educated in the world of native plants and vegetation. Many questions were asked and Martin was able to provide answers.

ANPC presenter Martin Driver giving an outline of native plant identification resources at the beginning of the day at the Barham reserve. Photo: Christine Dartnell.

Morning tea and lunch were provided for the group and everyone who attended the workshop seemed to have learnt more about native plants and their uses as well as having a great day out in the Barham Federation Botanic Reserve. The weather was perfect, the catering more than adequate, with Alan and Roger cooking the BBQ, and the company superb.

Future plans include seed collecting and plant propagation workshops to assist us and other property owners with improving biodiversity and sustainable land management. Thank you to Murray Local Land Services for giving the Landcare Group the grant and support to conduct this workshop.

News

Tweed – Byron Native Species Planting Guide – 2016-2018

JOHN TURNBULL
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Tweed and Byron Shire Councils, successful applicants to the 2015 NSW Environmental Trust (ET) Education Grants program, will, with their project partners Brunswick Valley Landcare Inc. (BVL Inc.), Tweed Landcare Inc., Rous Water, Nursery & Garden Industry NSW & ACT, local native plant nurseries and garden clubs, use the $50,000 awarded to deliver a project to produce:

- a user friendly online Native Species Planting Guide;
- an allied mobile phone application; and
- an updated "*My Local Native Garden*" booklet.

The data that will populate the online resource was compiled during the successful ET funded *Tweed Byron Bush Futures Project* (Underwood & Turnbull, 2012). It is currently available in spreadsheet format on the Councils' websites. The spreadsheet contains over 1,570 species known or believed to occur with the Shires and 124 selectable criteria for each species.

Selectable criteria include physical attributes (e.g. height, habit, growth rate), environmental tolerances (e.g. sun, frost, salt and wind hardiness), ecological relationships (e.g. key fauna food, butterfly and bird attracting, susceptibility to Myrtle rust), soil types on which species occur and broad landscape locations (e.g. hinterland, coastal lowland). In addition species are assigned to vegetation mapping types for both Shires and an "availability" score.

While the data is extensive it is not readily interrogated by many potential users and the conversion process is expected to allow for broader accessibility and uptake, more easily targeted searches and improved planting list compilation outcomes. The current data will be "cleaned-up" prior to conversion to aid this process.

The "My Local Native Garden" booklet produced by BVL Inc. in 2011, with NSW ET funding, provides less experienced gardeners with printed information regarding the use of native species for promoting biodiversity, a basic garden design and planting guide and an overview of broad landscapes and indicative associated species that link directly to the online Guide. Proposed updates will include Tweed landscape information and water conservation measures.

**The Tweed Shire floral emblem, Durobby (*Syzygium moorei*)
Photo: J. W. S. Turnbull**

Use of the online interactive resources and booklet will be promoted through a series of workshops, field days and other events. It is anticipated that the resources will assist gardeners, landscapers, developers, land managers, Council staff and bushland restoration professionals to make better informed plant selection decisions for projects ranging from landscape-scale restoration to garden plantings that will provide habitat for native fauna and potentially reduce exotic weed infestations.

The project commenced in February 2016 and will run for two years; the conversion of the existing data to mobile phone and online formats and the reproduction of the booklets are scheduled for release in early 2017 with targeted workshops to follow later that year.

It is anticipated that the Native Species Planting Guide will remain a living document that will be regularly updated with new records and search criteria as data becomes available and in response to user feedback.

Reference

Underwood, A. and Turnbull, J. (2012). Tweed Byron Bush Futures Project: improving urban and peri-urban bushland sustainability in Tweed and Byron Shires. *Australasian Plant Conservation*, 21(1),7-9.

Research Roundup

COMPILED BY KIRSTEN COWLEY

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Auerbach, N.A., Wilson, K.A., Tulloch, A.I.T., Rhodes, J.R., Hanson, J.O. & Possingham, H.P. (2015). **Effects of threat management interactions on conservation priorities.** *Conservation Biology* 29(6): 1626-1635. doi: 10.1111/cobi.12551

Baker, A.G. & Catterall, C. (2016). **Managing fire-dependent vegetation in Byron Shire, Australia: Are we restoring the keystone ecological process of fire?** *Ecological Management & Restoration* 17(1): 47-55. doi: 10.1111/emr.12194

Balding, M. & Williams, K. (2016). **Plant blindness and the implications for plant conservation.** *Conservation Biology* doi: 10.1111/cobi.12738

Bertacchi, M.I.F., Amazonas, N.T., Brancalion, P.H.S., Brondani, G.E., de Oliveira, A.C.S., de Pascoa, M.A.R. & Rodrigues, R.R. (2016). **Establishment of tree seedlings in the understory of restoration plantations: natural regeneration and enrichment plantings.** *Restoration Ecology* 24(1): 100-108. doi: 10.1111/rec.12290

Bonanno, G. (2016). **Alien species: to remove or not to remove? That is the question.** (2016). *Environmental Science & Policy* 59: 67-73. http: //dx.doi.org/10.1016/j.envsci.2016.02.011

Bradbury, D., Tapper, S.-L., Coates, D., McArthur, S., Hankinson, M. & Byrne, M. (2016). **The role of fire and a long-lived soil seed bank in maintaining persistence, genetic diversity and connectivity in a fire-prone landscape.** *Journal of Biogeography* 43: 70-84. doi: 10.1111/jbi.12601

Bradbury, D., Tapper, S.-L., Coates, D., Hankinson, M., McArthur, S. & Byrne, M. (2016). **How does the post-fire facultative seeding strategy impact genetic variation and phylogeographical history? The case of *Bossiaea ornata* (Fabaceae) in a fire-prone mediterranean-climate ecosystem.** *Journal of Biogeography* 43: 96-110. doi: 10.111/jbi.12615

Brundett, M.C. (2016). **Using vital statistics and core-habitat maps to manage critically endangered orchids in the Western Australian wheatbelt.** *Australian Journal of Botany* 64: 51-64. http://dx.doi.org/10.1071/BT15087

Cole, I.A., Prober, S., Lunt, I. & Koen, T.B. (2016). **Nutrient versus seed bank depletion approaches to controlling exotic annuals in threatened Box Gum woodlands.** *Austral Ecology* 41: 40-52. doi.10.1111/aec.12293

Cook, C.N., de Bie, K., Keith, D.A. & Addison, P.F.E. (2016). **Decision triggers are a critical part of evidence-based conservation.** *Biological Conservation* 195: 46-51. http://dx.doi.org/10.1016/j.biocon.2015.12.024

Crouzeilles, R. & Curran, M. (2016). **Which landscape size best predicts the influence of forest cover on restoration success? A global meta-analysis on the scale of effect.** *Journal of Applied Ecology* 53: 440-448. doi: 10.1111/1365-2664.12590

Dodd, A.J., McCarthy, M.A., Ainsworth, N. & Burgman, M.A. (2016). **Identifying hotspots of alien plant naturalisation in Australia: approaches and predictions.** *Biological Invasions* 18: 631-645. doi: 10.1007/s10530-015-1035-8

Driscoll, D.A., Bode, M., Bradstock, R.A., Keith, D.A., Penman, T.D. & Price, O.F. (2016). **Resolving future fire management conflicts using multicriteria decision making.** *Conservation Biology* 30(1): 196-205. doi: 10.1111/cobi.12580

Ferguson, I., Levetan, L., Crossman, N.D. & Bennett, L.T. (2016). **Financial mechanisms to improve the supply of ecosystem services from privately-owned Australian native forest.** *Forests* doi: 10.3390/f7020034

Fitzsimons, J.A. (2015). **Private protected areas in Australia: current status and future directions.** *Nature Conservation* 10: 1-23. doi: 10.3897/natureconservation.10.8739

Green, K. (2016). **Dieback of *Nematolepis ovatifolia* (Rutaceae), an endemic shrub in the alpine- subalpine heaths of the Snowy Mountains, is facilitated by climate change.** *Cunninghamia* 16: 1-9. doi: 10.7751/cunninghamia.2016.16.001

Greiner, R. (2016). **Factors influencing farmers' participation in contractual biodiversity conservation: a choice experiment with northern Australian pastoralists.** *Agricultural and Resource Economics* 60: 1-21. doi: 10.1111/1467-8489.12098

Heagney, E.C., Kovac, M., Fountain, J. & Conner, N. (2016). **Socio-economic benefits from protected areas in southeastern Australia.** *Conservation Biology*: 29: 1647-1657. doi: 10.1111/cobi.12554

Hinsley, A., Lee, T.E., Harrison, J.R. & Roberts, D.L. (2016). **Estimating the extent and structure of trade in horticultural orchids via social media.** *Conservation Biology* doi: 10.1111/cobi.12721

Ikin, K., Tulloch, A., Gibbons, P., Ansell, D., Seddon, J. & Lindenmayer, D. (2016). **Evaluating complementary networks of restoration plantings for landscape-scale occurrence of temporally dynamic species.** *Conservation Biology* doi: 10.1111/cobi.12730

Jones, M.M., Gibson, N., Yate, C., Ferrier, S., Mokany, K., Williams, K.J., Manion, G. & Svenning, J.-C. (2016). **Underestimated effects of climate on plant species turnover in the Southwest Australian Floristic Region.** *Journal of Biogeography* 43: 289-300. doi: 10.1111/jbi.12628

Kirkpatrick, J.B. & Bridle, K.L. (2016). **Grazing and the absence of fire promote the dominance of an unpalatable shrub in a patch mosaic cyclic successional system.** *Australian Journal of Botany* 64: 45-50. http://dx.doi.org/10.1071/BT15162

Loxdale, H.D., Davis, B.J. & Davis, R.A. (2016). **Known knowns and unknowns in biology.** *Biological Journal of the Linnean Society* 117: 386-398.

Mackey, B., Jacobs, P. & Hugh, S. (2015). **Classifying and mapping the Australian Alps' native vegetation.** *Cunninghamia* 15: 185-199. doi: 10.7751/cunninghamia.2015.15.010

Millar, M.A., Byrne, M., Coates, D.J. & Roberts, J.D. (2016). **Contrasting diversity and demographic signals in sympatric narrow-range endemic shrubs of the south-west Western Australia semi-arid zone.** *Biological Journal of the Linnean Society* 118: 315-329.

Moore, T.L., Ruthrof, K.X., Craig, M.D., Valentine, L.E., Hardy, G.E.St J. & Fleming, P.A. (2016). **Living (and reproducing) on the edge: reproductive phenology is impacted by rainfall and canopy decline in a Mediterranean eucalypt.** *Australian Journal of Botany* 64: 129-141. http://dx.doi.org/10.1071/BT15004

Morris, E.C., de Barse, M. & Sanders, J. (2016). **Effect of burning and rainfall on former agricultural land with remnant grassy woodland flora.** *Austral Ecology* 41: 74-86. doi: 10.1111/aec.12300

Nakahama, N., Hirasawa, Y., Minato, T., Hasegawa, M., Isagi, Y. & Shiga, T. (2015). **Recovery of genetic diversity in threatened plants through use of germinated seeds from herbarium specimens.** *Plant Ecology* 216: 1635-1647. doi: 10.1007/s11258-015-0547-8

Norton, D.A. & Young, L.M. (2016). **Effect of artificial shade and grazing removal on degraded grasslands: implications of wood restoration for herbaceous vegetation.** *Ecological Management & Restoration* 17(2) doi: 10.1111/emr.12205

Porqueddu, C., Ates, S., Louhaichi, M., Kyriazopoulos, A.P., Moreno, G., del Pozo, A., Ovalle, C., Ewing, M.A. & Nichols, P.G.H. (2016). **Grasslands in 'Old World' and 'New World' Mediterranean-climate zones: past trends, current status and future research priorities.** *Grass and Forage Science* 71: 1-35. doi: 10.1111/gfs.12212

Reiter, N., Whitfield, J., Pollard, G., Bedggood, W., Argall, M., Dixon, K., Davis, B. & Swarts, N. (2016). **Orchid re-introductions: an evaluation of success and ecological considerations using key comparative studies from Australia.** *Plant Ecology* 217: 81-95. doi: 10.1007/s11258-015-0561-x

Roberts, D.G., Forrest, C.N., Denham, A.J. & Ayre, D.J. (2016). **Varying levels of clonality and ploidy create barriers to gene flow and challenges for conservation of an Australian arid-zone ecosystem engineer, *Acacia loderi*.** *Biological Journal of the Linnean Society* 118: 330-343.

Seahra, S.E., Yurkonis, K.A. & Newman, J.A. (2016). **Species patch size at seeding affects diversity and productivity responses in establishing grasslands.** *Journal of Ecology* 104: 479-486. doi: 10.1111/1365-2745.12514

Start, A.N. (2015). **The mistletoe flora of southern Western Australia, with a particular reference to host relationships and fire.** *Australian Journal of Botany* 63: 636-646 http://dx.doi.org/10.1071/BT15028

Strickland, C., Liedloff, A.C., Cook, G.D., Dangelmayr, G. & Shipman, P.D. (2016). **The role of water and fire in driving tree dynamics in Australian savannas.** *Journal of Ecology* doi: 10.1111/1365-2745.12550

Tengia, B., Taylor, M. & Kirkpatrick, J. (2016). **Conservation tool or threatening process? Management implications of interactions of cattle with vegetation and land at the Vale of Belvoir reserve.** *Ecological Management & Restoration* 17(2) doi: 10.1111/emr.12204

Tolhurst, K.G. & McCarthy, G. (2016). **Effect of prescribed burning on wildfire severity: a landscape-scale case study from the 2003 fires in Victoria.** *Australian Forestry* 79(1): 1-14. http://dx.doi.org/10.1080/00049158.2015.1127197

Tozer, M. & Chalmers, A. (2015). **Should Hunter Valley Weeping Myall Woodland in the Sydney Basin Bioregion be listed as a Threatened Ecological Community?** *Cunninghamia* 15: 201-204. doi: 10.7751/cunninghamia.2015.15.011

Tulloch, A.I.T., Barnes, M.D., Ringma, J., Fuller, R.A. & Watson, J.E.M. (2016). **Understanding the importance of small patches of habitat for conservation.** *Journal of Applied Ecology* 53: 418-429. doi: 10.1111/1365-2664.12547

Turnhout, E., Lawrence, A. & Turnhout, S. (2016). **Citizen science networks in natural history and the collective validation of biodiversity data.** *Conservation Biology* doi: 10.1111/cobi.12696

Wang, Y. & Onal, H. (2016). **Optimal design of compact and connected nature reserves for multiple species.** *Conservation Biology* 30(2) doi: 10.1111/cobi.12629

Warman, R.D. & Nelson, R.A. (2016). **Forest conservation, wood production intensification and leakage: an Australian case.** *Land Use Policy* 52: 353-362. http://dx.doi.org/10.1016/j.landusepol.2015.12.020

Watson, J.E.M., Darling, E.S., Venter, O., Maron, M., Walston, J., Possingham, H.P., Dudley, N., Hockings, M., Barnes, M. & Brooks, T.M. (2016). **Bolder science needed now for protected areas.** *Conservation Biology* 30(2) doi: 10.1111/cobi.12645

Zivanovic, A.J. & Luck, G.W. (2016). **Social and environmental factors drive variation in plant and bird communities across urban greenspace in Sydney, Australia.** *Journal of Environmental Management* 169: 210-222. http://dx.doi.org/10.1016/j.jenvman.2015.11.052

Zuo, A., Wheeler, S.A. & Edwards, J. (2016). **Understanding and encouraging greater nature engagement in Australia: results from a national survey.** *Journal of Environmental Planning and Management* 59(6): 1107-1125. http://dx.doi.org/10.1080/09640568.2015.1054926

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KEYNOTE SPEAKER:

Gregory Andrews
Commonwealth Threatened Species Commissioner

PLENARY SPEAKERS:

Dr Jen Silcock
University of Queensland

Dr David Kendal
University of Melbourne

Dr Paul Gibson-Roy
Greening Australia, NSW

Ms Leonie Monks
WA Dept of Parks and Wildlife

AUSTRALIAN NATIONAL BOTANIC GARDENS

The endangered Caladenia fulva (Tawny Spider-orchid) is only known to occur in the Stawell area in the Victorian goldfields region. Photo credit: Noushka Reiter
Pelargonium striatellum (Omeo Stork's-bill) is known from only one population in Victoria at Lake Omeo, and four locations in southern NSW. Photo credit: RO Makinson